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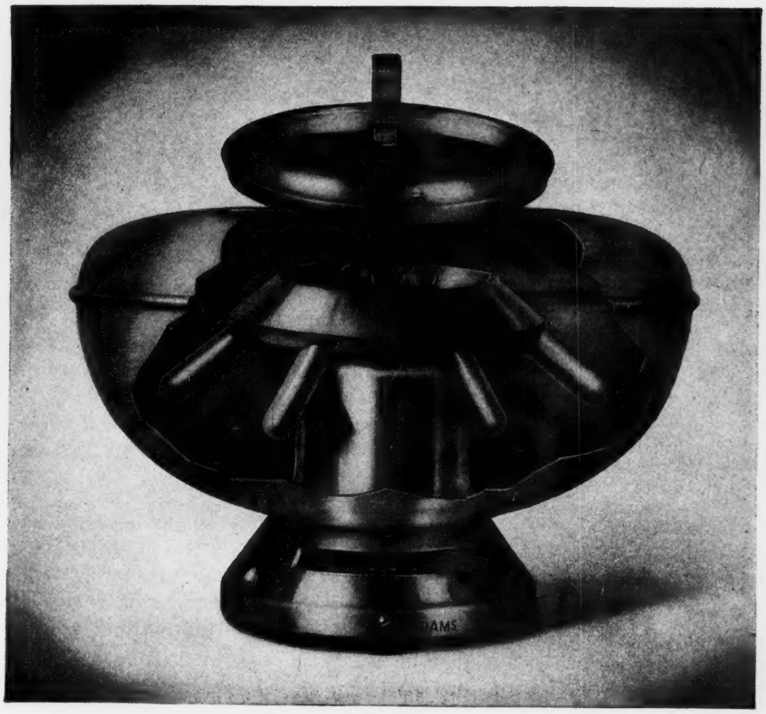

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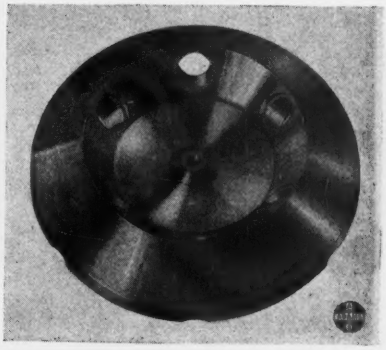

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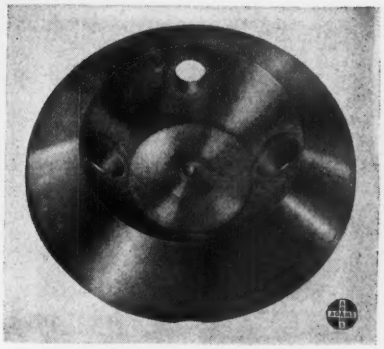

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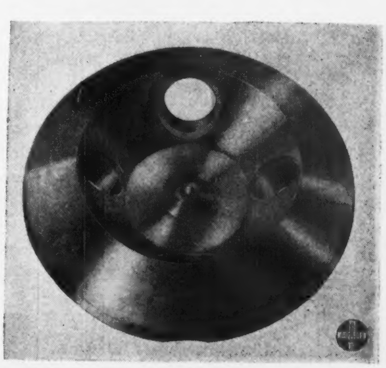

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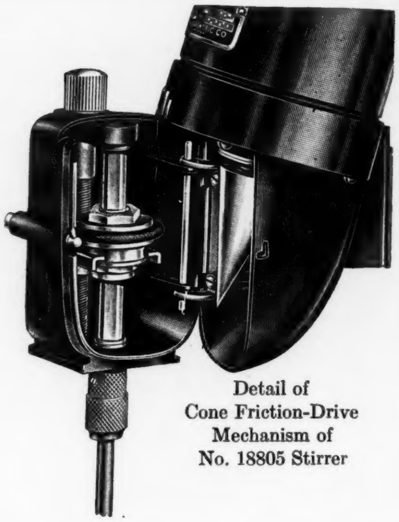

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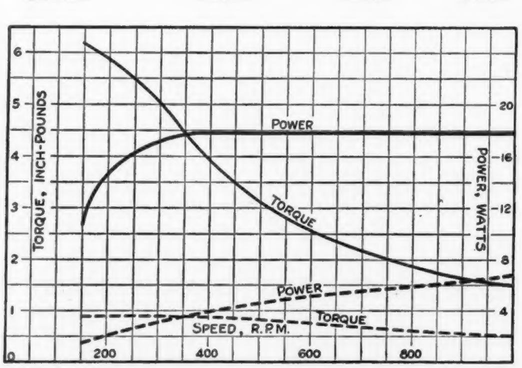

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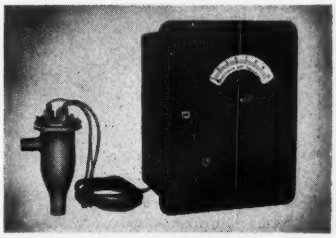

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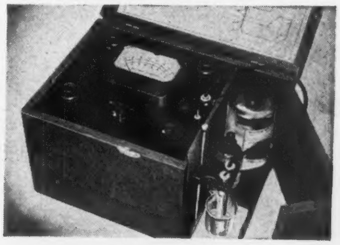

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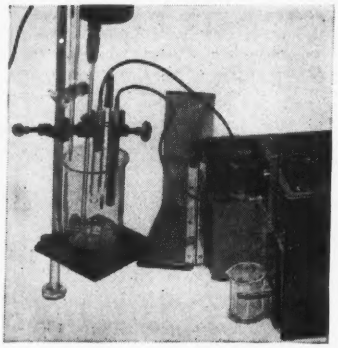

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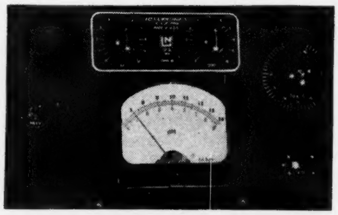

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(For further information, see the article, "The Founding of the American Chemical Society," by William F. Ehret, on page 170.)

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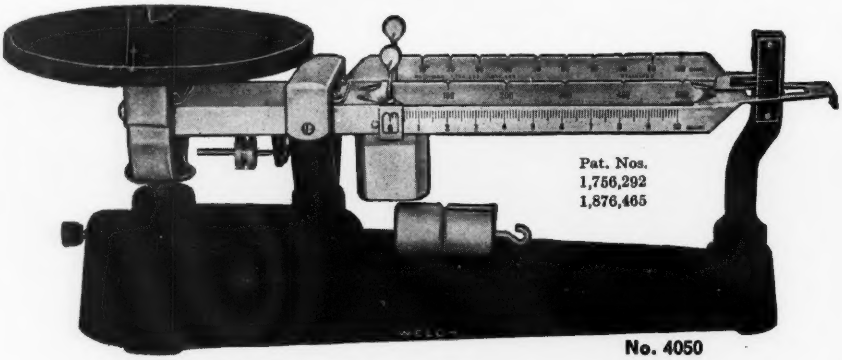

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Editor's Outlook

IT IS fatuous to subscribe unreservedly to the doctrine that our misfortunes are but blessings in disguise. Nevertheless there is reason to hope and believe that some good may after all come from the present national emergency.

Not only in the field of industrial production are the wheels beginning to hum; the process of throwing the machinery into high gear produces acceleration and flow of power all along the line. We are not only experiencing an economic surge but a mental and emotional one as well.

It is unfortunate that the threat and fear of war are necessary to bring us around to doing things which should have been done without the compulsion, but at least we can recognize our opportunity and capitalize on it. A lot of social and educational ideas have been simmering on the fire for quite a while, without anyone bothering to turn on the heat. Now that the urge for action is in the air maybe something will be done about them.

There are indications that we are beginning to look at our educational structure as we would at our current model of air-bomber, trying to streamline it better, increase its power and performance—in short, to increase the "lift" and cut down the "drag."

Education, in its restricted, as well as its broader meanings, is going to play a tremendous part in our "all-out" efforts to meet the demands of Preparedness through Production.

William S. Knudsen, in a recent letter to the National Association of Manufacturers, said that the call was for an all-out performance of American ingenuity, backed by every machine and piece of equipment. But men have to operate these machines, and their rapid and adequate training is an educational task of no mean proportions. Already the enrolment in existing trade-school classes and the establishment of new ones have jumped enormously. The College of Engineering of Cornell University reports the organization of evening and Saturday classes not only in Ithaca but also in Elmira and Buffalo. In Pennsylvania the State program of Vocational Education for National Defense provides for the vocational education of defense workers through pre-employment refresher and supplementary courses; also for training of employes on National Youth Administration projects, as well as vocational education for national defense for out-of-school rural and non-rural youth.

The impetus from having something tangible to work for. even though the ultimate objective is not a very encouraging one, is bringing us together and centering our attention on things which are presently and ultimately important. Everyone will have a job, will realize the importance of *his* job, and will strive to fit himself better to accomplish it. The result of this intensity will make itself felt in other fields than preparedness for national defense.

Even the dislocation of thousands of young lives which will result from the enforced year of military training, while it will make necessary the postponement of other plans, will have some compensations. Many will get vocational training which they would not otherwise have had and will come out better equipped for future life.

We are in a time of national "stock-taking"; nearly every educational institution is surveying itself critically to see what its particular contributions to the national cause are and can be. Some are in no position to take part in the type of industrial training that is most immediately productive of results. But there are other things to be done. Perhaps *your* school or institution has some special activity, scientific or otherwise, in connection with the national defense program. If so, please tell us about it. News about significant courses, modifications in teaching, projects, or special training will be welcome for publication. Others may profit by your experience.

In our zeal for vocational training, however, let us not lose sight of the need for cultivating in our young people an appreciation for the leisure-time pursuits. This can be as permanent a contribution to their education as the opportunity to acquire technical skill.

And, ultimately, what? We found this phase of the problem very well put recently:[1]

> "And what of the future? Shall we always need tanks, warplanes, and anti-aircraft guns in the measure for which we are at present appropriating federal monies? Let us hope not! Will the millions of boys who will receive technical training within the next few years to meet the existing defense emergency have jobs ten years hence? Can we afford to throw them into an army of unemployed? Or must we engage in war perpetually to give them occupation? These are questions a democracy must answer. A dictatorship need not."

The problem of deferment of training is one that must be settled soon, in the national interest as well as that of the individuals concerned. It will not be easy to do it consistently with our feelings about democracy and equality of opportunity. If the object is the mobilization of the nation's resources to meet a possible crisis most effectively, it cannot be accomplished by adhering to the doctrine of similar treatment for all, irrespective of training, capacity, or standing. The last war showed the folly of that, and the British, with their well-organized system of occupational registration and assignment, have profited by the lesson.

We cannot strip our colleges of the young prospective chemists, engineers, and doctors, and be "prepared" in an industrial or military sense for any long stretch of time. And the truth of course is that at this stage we do not know just what we are preparing for.

It is encouraging to note the high state of morale of the young people in our colleges today, notwithstanding the uncertainty of their immediate future. For

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[1] PLATT AND PLATT, "Technical education: non-Nazi style," *High Points*, **22**, 5 (Dec., 1940).

the moment, the notorious provincialism and "intramuralism" of our colleges is standing us in good stead. There will be enough confused running to and fro for a time yet, without a few thousand more college boys added to the throng. But from now on it will be an increasing problem for our educational institutions to convince their students that the things they are now doing are worth while, immediately as well as ultimately. It will be harder and harder to persuade them of the pertinence of the letter of the President of the United States, which we published in the October, 1940, number of the JOURNAL.

What's Been Going On

IN 1914 the average production of gasoline amounted to 14 per cent of the crude, as contrasted to about 75 per cent now being obtained in the modern refineries.

The fermentation of gasoline by bacteria to yield 10 per cent methane and 90 per cent ethane has been reported by Dr. A. C. Thaysen, eminent British bacteriologist.

It is reported that vitamin preparations now occupy third place in the drugstore field, which is another way of saying that the present generation is certainly vitamin conscious. The newest addition to the vitamin family is vitamin M, found at present only in liver, according to the National Live Stock and Meat Board.

By the Velo cold set process of printing, the ink dries almost instantaneously because the hot ink solidifies as soon as it comes in contact with the paper. This prevents the spread or penetration of the ink with the use of softer and coarser papers.

The paper used by the Western Union facsimile apparatus for transmitting written or typed messages acts as an electrical conductor. It is blackened locally by the passage of a current and the original message is reproduced. This is made possible by special chemical treatment of the paper.

The production of rayon started in 1911 and it took eleven years for annual production to reach 15,000,000 pounds, whereas the manufacture of nylon is expected to exceed this annual production figure in less than two years from the time of its introduction on the market.

"Tempered" nylon, which is both transparent and flexible, is obtained by extruding hot filaments from a spinnerette into a cold bath of water or other appropriate liquid. By depositing molten nylon, through a slot orifice, on the smooth surface of a cooled drum, dry "tempering" is obtained. The sheets produced in this manner may be used as aircraft windshields, currency and policy paper, film for safety glass, playing cards, photographic film base, and as window and lamp shades.

According to Professor Hibbert of McGill University, wood can undergo liquefaction, by subjecting it to high pressure, and can then be separated into its various chemical constituents.

Antioxidants such as benzylaminophenol, used in concentrations of less than 0.01 per cent, are now being used extensively to stabilize gasoline against gum formation and deterioration during storage.

The synthetic gasolines, of the 100-octane class, are produced almost entirely from the butanes and butenes obtained from the cracking process. Isobutylene may be polymerized to the dimer and then hydrogenated to give 2,2,4-trimethylpentane (isooctane), or isobutylene may be co-polymerized with *n*-butylene by the hot acid or phosphoric acid process to give a mixture which is hydrogenated to yield a fuel with a 92- to 98-octane rating, or isobutylene may be co-polymerized with isobutane in the presence of concentrated sulfuric acid to give mixed octanes (mostly, 2,2,4-trimethylpentane), or isobutane may be added to ethylene at a temperature of about 500° C. and a pressure of 5000 pounds to give 2,2-dimethylhexane (neohexane).

Since May 14, 1940, Java has been the center of the world's quinine industry, and ample production of both cinchona bark and manufactured quinine seems assured.

Indole is now being produced synthetically by E. I. du Pont de Nemours and Company.

The current story of synthetic rubber may be summarized as:

Starting Material	*Product*
1. Diolefin:	
a. Isoprene...............	Natural rubber
b. Butadiene, polymerized by Na...............	Buna (German product)
c. Dimethylbutadiene.....	Methyl rubber
d. Butadiene..............	SKA, SKB (Russian products)
2. Chloroprene (with or without modifiers)........	Neoprene
....	Sovprene
3. Diolefins with modifiers:	
a. Butadiene + styrene....	Buna S
b. Butadiene + acrylonitrile.................	Perbunan or Buna N
c. Butadiene + ?.........	Ameripol, Chemigum, Hycar, Synthal
4. Olefins + diolefins.........	Butyl rubber
5. Vinyl chloride + tricresylphosphate............	Koroseal
6. a. Ethylene dichloride + Na_xS_y................	Thiokol A
b. Dichloroethylether + Na_xS_y................	Thiokol B
7. Isobutylene................	Vistanex

By the end of 1941, the capacity for the production of neoprene will have reached 9000 tons annually, or about six times the available capacity in the summer of 1939.

A new plant is being built by Goodyear Tire and Rubber Company at Akron that will have a capacity of 5500 tons of Chemigum annually. Other expansions by various companies will soon give a total synthetic rubber capacity of about 100,000 tons annually, or approximately 20 per cent of the country's ordinary requirements for rubber.

Studies by Mills and Colvin, of the University of Cincinnati, indicate that vitamin B_1 may be an important factor in affording protection against the evil effects of excessive heat.

Soap exports during the first six months of 1940 amounted to 17,330,000 pounds compared to 12,750,000 pounds for the first six months of 1939. It looks like the world is trying to clean up.

The Meiji Mining Company is constructing a plant at Kushiro for the production of caustic soda, hydrogen, chlorine, and magnesium from sea water.

Rice straw is now being utilized by the Japanese in the production of furfural.

The Nissan Chemical Company is producing about one ton of synthetic tannin per day from cresol.

According to paint experts, objects appear lighter in weight if colored blue or yellow, but heavier if painted red or orange. This might be a cue for those interested in reducing.

The disturbance of the water balance in tissues of the body by falling barometric pressure, according to Dr. C. A. Mills of the University of Cincinnati School of Medicine, may have an effect on one's temperament.

If you wish to test your chemical I. Q., try "Howe's About It Questions" in the *News Edition* of *Industrial and Engineering Chemistry* for September, 1940, p. 810.

—ED. F. DEGERING

Lecture and Laboratory Notebooks of Three Early Irish-American Refugee Chemists[1]

William J. Macneven, John P. Emmet, and Thomas Antisell

C. A. BROWNE

Bureau of Agricultural Chemistry and Engineering, Washington, D. C.

THE influence of political disturbances on the exodus of chemists from Europe to the United States constitutes an important chapter in the history of chemistry in America. The list of European chemists who have been thus expatriated is a long one and the stories of their adventurous careers are filled with romantic interest. The name of Priestley is the most famous one on the list of chemists who came to America to escape persecution. The disturbances in Germany following the troubles of 1848 brought to America a large number of German chemists, whose contributions had much to do with the advancement of chemistry in the United States before the Civil War. A modern parallel of this movement is found in the exodus of chemists and other scientists from Germany to the United States as a result of the recent persecutions by the national socialistic government.

The struggles in Ireland for political freedom in the first half of the nineteenth century resulted in uprisings and banishments that caused a large number of eminent Irishmen to seek refuge in the United States. Three of these refugees, Dr. William James Macneven, Dr. John Patten Emmet, and Dr. Thomas Antisell, were physicians and chemists of note. The recent opportunity to inspect student notebooks of chemical lectures that were taken under Macneven and Emmet and a laboratory notebook that was kept by Antisell has caused the writer to prepare a short review of these chemical documents.

The earliest of these Irish refugees was Dr. William James Macneven, who was born at Ballynahowne, Ireland, March 21, 1763. At the age of ten he was invited by his uncle, Baron Macneven, who was court physician to Queen Maria Theresa at Vienna, to complete his education in Austria. He attended schools in Prague and Vienna, and in 1785 obtained his medical degree in Vienna at the age of twenty-two. He then returned to Ireland and took up the practice of medicine in Dublin. Having a gift for oratory and organization, Macneven became very active in founding the Order of United Irishmen. He was arrested and imprisoned in 1798 for sedition but was released under banishment in 1802.

After a sojourn in France, Macneven sailed for America, reaching New York July 4, 1805; here he began the practice of medicine. In 1806 he received the honorary degree of M.D. from Columbia College. In 1807 he began lecturing at the New York College of Physicians and Surgeons, in 1808 was appointed its Professor of Obstetrics, and in 1810 its Professor of Chemistry, to which chair the courses in Materia Medica were later added. In April, 1826, Macneven, with Dr. Samuel L. Mitchill and other professors, seceded from the College of Physicians and Surgeons to found the Rutgers Medical School which, however, was abolished in 1830.

(Edgar Fahs Smith Memorial Collection, University of Pennsylvania)

WILLIAM JAMES MACNEVEN

Macneven continued the practice of medicine in New York until 1838, when ill health compelled him to cease from further activity. In 1840 a fall, with injury to his leg, resulted in a long illness and finally in his death on July 12, 1841.

As a chemist, Macneven is best known for his early recognition of the importance of the atomic theory, of which he gave an exposition in Thomson's *Annals of Philosophy* for 1820. He published in 1821 an American edition of Brande's "Manual of Chemistry," of which a second edition appeared in 1826. He was the author of various papers on the chemical examination of waters, minerals, and other subjects, two of which were published in German. He was a public-spirited citizen, and in 1824 joined with his friend and fellow chemist, Dr. S. L. Mitchill, in founding the New York Athenaeum before which he lectured on applied chemistry. A tall shaft to Macneven's memory stands in St. Paul's Churchyard on lower Broadway. It is passed daily

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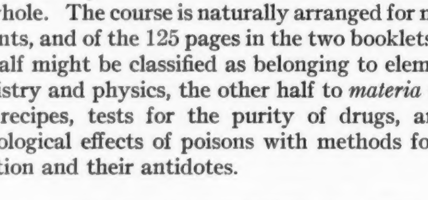
[1] Presented before the Division of the History of Chemistry at the ninety-eighth meeting of the A. C. S., Boston, Massachusetts, September 12, 1939.

by more people than the monument of any other American chemist. The inscription in English, Latin, and Gaelic states that "As Professor of Chemistry in the Medical Schools of this city he was one of the first and ablest teachers in America of those Discoveries and Doctrines which raised chemistry into a science and prepared it for future illimitable extension."[2]

We have numerous contemporaneous records about Macneven as a teacher but the only classroom records which I have thus far discovered are two small booklets of lecture notes that were taken by Thomas Arnold Brayton, a medical student, during the course of 1823–24 at the College of Physicians and Surgeons. These notes, which came into the writer's possession three years ago, are very fragmentary and cover a period of only about six weeks from the middle of January to the end of February, 1824. This and the very abbreviated, disorderly state of the notes make it impossible to form from them any idea of Macneven's course of lectures as a whole. The course is naturally arranged for medical students, and of the 125 pages in the two booklets about one half might be classified as belonging to elementary chemistry and physics, the other half to *materia medica* with recipes, tests for the purity of drugs, and the physiological effects of poisons with methods for their detection and their antidotes.



8. For salt Rheum Citrine Ointmt
Steam the part over hot water & then
apply it.
Mc Nevin 20th Feby
The vegetable & animal colours are without
Exception destroy'd by light and some
of the Mineral colours Solar heat
& Red light have same affect in
many cases—
Mc Nevin thinks that light is only
a Modification of heat
Chlorine & Hydrogen in the light
Explodes with violence
Some plants follow the sun as sun-
flower adapting themselves to the light
Vegetables in the light give out oxygen
in the dark Carbonic acid gas
Animals change their colours as
Rabits the Mc [illegible] to the Effect

PAGE FROM BRAYTON'S NOTES ON MACNEVEN'S LECTURE ON LIGHT AND COLOR FOR FEBRUARY 20, 1824

Macneven, as we know, was a man of very independent judgment and indications of his assertive nature are reflected at times in student Brayton's notes, who records carefully the opinion of Dr. William, or Macneven, or sometimes merely Mc, these no doubt being familiar designations of the lecturer among the student body. Brayton, for example, mentions in the lecture on blood that fibrin dissolved in dilute muriatic acid gives a blue color and then adds, "Mc thinks it is owing to the iron contained in the muriatic acid" (as an impurity). Again, in the lecture on light, Brayton records that solar heat and red light have the same effect in many cases and then adds "McNevin thinks that light is only a modification of heat." The theories of Newton and other philosophers regarding the nature of light are mentioned. Phosphorescent substances combine with light, light obeys the laws of attraction, and other arguments are advanced to indicate that light may be a material substance.

Macneven was renowned as an orator and his fondness for rhetorical effect no doubt made a strong appeal to the students of his classroom. Brayton records that light travels 200,000 miles a second, that the nearest fixed star is 400,000 times farther from us than the sun, and that a ray of light from this star would be six years in reaching us. Then follows this burst of eloquence: "How boundless then is nature! How wide is space! How great that Being who upholds, connects and governs all!"

Macneven's lectures were illustrated with numerous experiments which brought out carefully the point under discussion. Thus in discussing the use of silver nitrate as a tonic Brayton notes that this nitrate would be converted into the muriate by the common salt of the stomach. He then records the proof by an experiment, in which a pinch of salt is dissolved in a little water. "Drop into it a little nitrate of silver and a white precipitate falls. Therefore it is the muriate of silver." He then sets down this admonition of the lecturer: "Take care then how you draw your conclusions."

One of Macneven's lecture experiments showed how hydrogen sulfide gives an orange precipitate with salts of antimony, a yellow precipitate with salts of arsenic, and a black precipitate with salts of lead. The hydrogen sulfide in this experiment was produced by the action of sulfuric or muriatic acid on antimony sulfide. This being before the days of our present system of symbols and equations, the old lecturers had to explain their reactions by means of a rationale which in this case, as recorded by Brayton, was as follows: "The water is decomposed. The oxygen goes to the antimony and forms oxide of antimony; the hydrogen unites with the sulphur and forms sulphuretted hydrogen. The muriatic acid seizes the antimony (oxide) and forms muriate of antimony." This is strictly in line with the old conception that the primary step in all such reactions was the decomposition of water.

In the case of preparing hydrocyanic acid by the old process of Scheele the rationale is more complicated. Brayton gives two accounts of this, the one in his second notebook correcting certain omissions of that in his first. In this process a solution of yellow prussiate of

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[2] See illustration of monument in J. CHEM. EDUC., 9, 704 (1932).

potash is boiled with the red precipitate of mercury (mercuric oxide) until the red color of the oxide has disappeared. The explanation of this part of the reaction is that there is a double decomposition; the oxygen of the red precipitate leaves the mercury to combine with the iron of the prussiate, while the hydrocyanic acid leaves the prussiate to combine with the mercury of the red precipitate, forming cyanuret of mercury. The latter compound can be obtained in the crystalline form, if desired, by evaporating the filtered solution. Clean iron filings and sulfuric acid are then added to the filtered solution. Hydrogen is evolved, which combines with the cyanogen of the mercury compound to form hydrocyanic acid and metallic mercury. The hydrocyanic acid is then distilled off over a slow fire and condensed in a cold receiver with an outlet tube to conduct off the excess hydrogen. Such in brief is the rationale, as Macneven explained it to his class, of a reaction whose complicated details have engaged the attention of chemists for 150 years. In reviewing old chemistry notebooks of this period one is impressed by the great handicap under which both teacher and student worked in not having symbols and formulas by which the steps of chemical reactions could be plainly visualized.

Macneven was one of the earliest advocates of the atomic theory of Dalton, and stoichiometric calculations enter naturally into his explanations. Thus in the case of hydrogen sulfide, Brayton records that 100 cubic inches of the gas weigh 36 grains, of which 2.117 grains consist of hydrogen and 33.883 grains of sulfur. The ratio of 33.883 ÷ 2.117 is 16, which is the atomic equivalent of sulfur when hydrogen is unity.

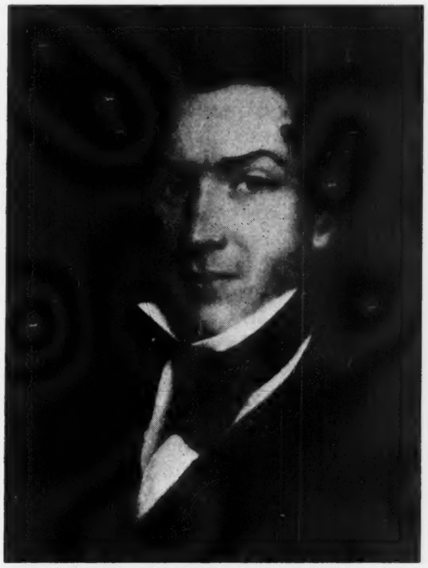
For collateral reading, Macneven referred students to Brande's chemistry, his own edition of this work being of course implied, as can be confirmed by checking the page references in Brayton's notes. For *materia medica* references, mention is made of Coxe's "Dispensatory," the first edition of which was published at Philadelphia in 1806.

Macneven scattered a few historical statements throughout his lectures, as when he alludes to Davy's discovery of nitrous oxide in his lecture on the oxides of nitrogen. Glimpses appear also in his lectures of observations made during his long residence in European countries, as when in his discussion of mineral waters he states that "gouty patients in Germany are cured by hot baths and for a considerable time."

Students' lecture notes often contain amusing statements and bits of pleasantry and so on an inside cover of one of Brayton's booklets are a few lines of comic verse which may, perhaps, have been recited by Macneven as a compliment to the army captain who once held him prisoner.

"When nature formed the fustian brain
Of this redoubted Captain vain
She had at hand but few ingredients
And so was forced to use expedients.
She put therein some small discerning,
A grain of sense, a grain of learning,
And when she saw the void behind
She filled it up with froth and wind."

The second chemist on our list of Irish refugees is Dr. John Patten Emmet, who has the distinction of having been the first Professor of Chemistry at the University of Virginia. He was born in Dublin on April 8, 1796, the second son of Thomas Addis and Jane Emmet, and was named after his mother's father, Reverend John Patten, a Presbyterian clergyman. Robert Emmet, the Irish orator and patriot, who was executed for sedition in 1803, was his uncle. Thomas Addis Emmet was educated to be a physician but gave up medicine for law. Like his brother Robert, he was one of the leaders of the United Irishmen party, but his political activities led to banishment in 1802. After spending two years with his family on the continent he sailed in October, 1804, for New York, where he resumed the practice of law and became one of the leaders of the American bar.



(From "The Emmet Family," by T. A. Emmet, New York City, 1898[3]*)*

JOHN PATTEN EMMET

John Patten Emmet, the son of Thomas Addis Emmet, entered West Point after a course in the schools of Newburg but delicate health obliged him to leave the Academy and give up a military career. After a year of travel and study in Europe he returned to New York. He completed the medical course at the College of Physicians and Surgeons in New York, where he heard the chemical lectures of his father's intimate friend and fellow propagandist for Irish freedom, Dr. William Macneven. There were thus, naturally, close ties of friendship between Macneven and young Emmet, which were further cemented by the fact that Macneven's

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[3] Photograph reproduced through courtesy of the Alderman Library, University of Virginia.

stepdaughter was the wife of Emmet's brother. Macneven made Emmet his laboratory assistant, and this position he filled until his graduation from the College of Physicians and Surgeons in the year 1822, with a thesis of 125 octavo pages on the "Chemistry of Animated Matter."

After a brief residence in Charleston, South Carolina, Emmet accepted a position as Professor of Natural Philosophy in the newly established University of Virginia in 1825, when the courses of this University were first opened to students. In 1827 Emmet's professorship was changed to that of Chemistry and Materia Medica. During his connection with the University he not only conducted the courses in chemistry but also published various papers in the *American Journal of Science*. His contributions related to such subjects as "Iodide of Potassium as a Test for Arsenic," "The Solvent and Oxidating Powers of Ammoniacal Salts," "Bromine and Iodine in Kanawha Salts," "On Formic Acid," and "The Solidification of Raw Gypsum."

In 1834 Emmet purchased a tract of land adjoining the University grounds where he devoted his leisure to growing flowers and fruits, to the production of wine, and to experiments on the culture of silk. In January, 1842, failing health obliged him to visit Florida. In May he felt well enough to sail for New York, but a storm off Cape Hatteras dismantled his ship, which drifted helplessly about for thirty-eight days before it was rescued and taken to New York. The hardships of this experience so reduced Emmet's strength that he died on August 15, 1842, at the early age of forty-six.

The lecture notes of Professor Emmet's chemical course at the University of Virginia, which it has been my privilege to examine, were written by Haller Nutt in the session of 1833–34. (Like Brayton's notes of Macneven's lectures, the work of Nutt is a fragment from which no idea can be formed of the course as a whole.) The notes are neatly written and fairly complete so far as they go, but there are large gaps with vacant pages left for the insertion of missing lectures which from illness, or the flagging of good intentions, were never written up.[4]

Of the fifty pages of notes in Nutt's book, forty-three relate largely to lectures on heat, light, and electricity. Chapter 13, of seven pages, is the first and only lecture recorded in what is termed "Chemistry Proper." In reading these notes one is impressed first of all by the large amount of attention which Emmet gave, by mention and demonstration, to apparatus. We know from the tribute to Emmet by Benjamin Silliman, Jr., that he was an ingenious experimenter and the inventor of original apparatus in the field of magnetism and electricity. Dr. J. Lawrence Smith, who in 1852 was called to the Professorship of Chemistry at Virginia, informed Silliman that "Dr. Emmet left valuable and extended notes of original experiments on light and other subjects which have not yet been published." Nutt's notebook throws an interesting sidelight on this phase of Emmet's scientific attainments. At the beginning of the very first lecture on the properties of matter the importance of apparatus is emphasized. In the third sentence of his notebook Nutt writes:

> "It is exceedingly difficult to tell the properties of matter—thus as an example we live a long time in the air without knowing its properties and unless assisted by proper apparatus never would find them out."

Among the pieces of apparatus referred to by Nutt in his notes of Emmet's lectures are the goniometers of Hauy and of Wollaston; the parabolic reflector; Leslie's apparatus for measuring the absorption of solar radiation by different surfaces; Franklin's device for comparing the absorption of heat by differently colored bodies; Wollaston's cryophorus; Daniel's hygrometer; the barometer; the Reaumur, Centigrade, and Fahrenheit thermometers; Rutherford's registering thermometer; Leslie's thermometer; Wedgwood's pyrometer; Dufey's electrical machine; the Leyden jar; Franklin's lightning conductor; Galvani's device for showing the effect of electricity on muscular action; Volta's electric pile; Volta's *Couronne des tasses* or series of electric cells; Cruikshank's trough battery; Wollaston's battery; Hare's calorimeter; Oersted's galvanometer; the pneumatic trough; the gasometer; and various other experimental devices. In fact Emmet's lectures, so far as one can judge from Nutt's record book, seem to have been built largely around demonstrations of apparatus. A few of these notebook allusions to Emmet's demonstrations are quoted.

The first selection relates to Emmet's demonstration of the barometer:

> "Dr. Emmet showed the class an instrument for the measurement of heights. It is on the plan and principle of the barometer. Observe how high the mercury will rise at the bottom of a mountain for example—the difference of the heights of mercury marked on the stem of the instrument will give the height of the mountain—the smaller the base of the instrument the more sensible the instrument. Dr. Emmet suggested an improvement, which is to bend the tube at right angles and when the mercury rises in the tube to catch what flows over and weigh it and thus find the height of the mountain."

One of Emmet's experiments was of a rather unusually gruesome character. The following is quoted from Nutt's lecture notes on galvanism:

> "The Science of Galvanism is about 40 years old—it was twenty-two years after this before they had any method of ascertaining the proper force of galvanic fluid. The galvanometer is the best instrument for examining its properties and which shows its connection with magnetism—matter while under the influence of galvanism has all its other properties suspended. Set galvanism in motion and chemical separation takes place. Galvanism interferes with cohesion, attraction, etc. The nerves of the human system have been found to be very fine conductors of this fluid and cause a great excitement of the muscles. Dr. Emmet tried its effect upon a negro that was hung about half an hour after he was dead—we saw that there was no effect while the communication was entire."

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[4] So many notebooks of chemical lectures start off bravely but begin to deteriorate before the course is half completed. The most perfect and complete notebook of chemical lectures that exists is the one made of Liebig's lectures by Kekulé, which is preserved in the Kekulé Zimmer at Darmstadt, and of which photographic facsimiles are available at 100 marks each.

The treatment of light, heat, and electricity as imponderable chemical elements, adopted by Lavoisier and continued by most chemists for the next forty years, was followed by Emmet, although the practice in the late 1830's began to be abandoned. The early followers of Lavoisier supposed the gaseous elements, oxygen, hydrogen, nitrogen, etc., to be compounds of the element with caloric which was driven out when the gas was compressed or entered into chemical combination. Nutt writes in his first lecture:

> "The quantity of heat in a body is infinite since continued heat may be produced by friction. If after a great quantity of caloric has been produced, we weigh the body rubbed, we will find its weight not lessened—hence we conclude that caloric is imponderable, altho this may not be philosophically true."

The number of simple substances or elements is given by Nutt as fifty-three. They are classified into the electronegative, which comprise oxygen, chlorine, bromine, iodine, and fluorine, and the electropositive, which comprise hydrogen, nitrogen, sulfur, selenium, phosphorus, carbon, boron, and the metals. This division, it is stated, is only relative, however, since chlorine is mentioned as being negative with respect to one element and positive with respect to another. Historical matters are given due consideration, an entire page, for example, being devoted to the phlogiston theory of Stahl. The contributions of Priestley, Scheele, and Lavoisier are also mentioned. Stahl's ideas are thus peculiarly summarized:

> "Had Stahl said that Phlogiston was a principle which was *added* to every substance by combustion, and *not taken away*, his theory would have been as good as Lavoisier's. In fact it would have been the same except with regard to the name. *See the vast importance of a word.*"

We can dwell no longer upon the notebooks of Emmet's lectures, which, we wish, might have been recorded more completely, and now pass on to consider a third chemist of the Irish political refugees. This is Dr. Thomas Antisell, who was born of French Huguenot ancestry in Dublin on January 16, 1817, and was educated at Trinity College of that city. He then studied at the Dublin School of Medicine and the Irish Apothecary's Hall, where he obtained his first chemical instruction under the well-known chemist, Sir Robert Kane. Antisell's medical education was completed at the Royal College of Surgeons in London, from which he obtained his medical degree in November, 1839. After a semester in the chemical laboratory of Pelouze in Paris he became assistant to his former teacher Kane, with whom he remained three years. In 1844 he continued his chemical studies on the continent under such eminent teachers as Pelouze, Biot, Dumas, and Berzelius. He then began the practice of medicine in Dublin, but, becoming involved in the political activities of the "Young Ireland Party," was sentenced to exile and imprisonment. He avoided this penalty, however, by escaping to America as surgeon on an outgoing vessel. His career as traveling student, doctor, chemist, Irish political agitator, exile to America, and patriotic citizen of the United States tallied exactly with that of his fellow countryman Macneven of a generation before.

Antisell landed in New York on November 22, 1848, and practiced medicine in that city for the next six years with occasional intermissions when he lectured on chemistry at the Berkshire Medical Institution in Pittsfield, Massachusetts, and at the Medical College of Woodstock, Vermont. He became quickly identified with the civic affairs of his new home and during the twenty-second annual fair of American Institutes at Castle Garden in October, 1849, delivered a series of addresses on "The Philosophy of Manufactures." He compiled also, in 1852, a "Cyclopedia of the Useful Arts," a convenient 690-page illustrated handbook of progress and invention in different branches of applied science. It was a work requiring wide knowledge and great labor.

In 1854 he dropped his medical practice to become geologist under Lieutenant J. G. Parke in command of the Pacific Railroad survey. Antisell's geological reconnaisance of Southern California and the Arizona Territory was published in 1856 in Volume Seven of "United States Explorations and Surveys," of which a review is given in the 1904 *Report of the Smithsonian Institution* (pp. 453–5). After terminating this geological expedition Antisell came to Washington, where on June 1, 1856, he was appointed first assistant examiner in the Patent Office. In connection with his duties as examiner he operated a small chemical laboratory in the basement of the old Patent Office building.

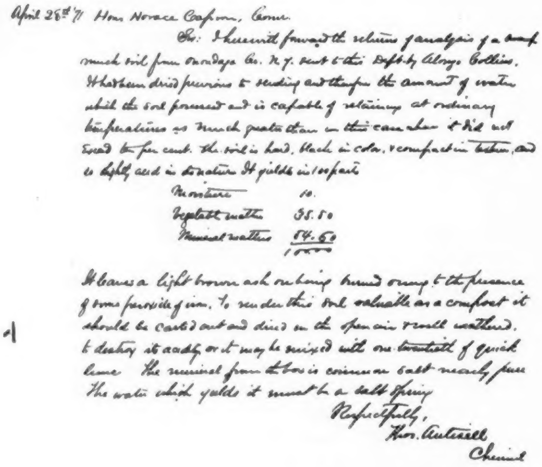
Between the years 1842 and 1862 the Patent Office, in addition to its regular activities, discharged the agricultural functions of the Government, and Antisell, in the midst of his other duties, devoted a part of his time to the chemical examination of soils and other agricultural products.

Antisell, whether working as chemist or geologist or patent examiner, could never forget that he was first of all a physician and very soon after his arrival in Washington he began lecturing to the medical students of Georgetown College on chemistry, toxicology, and physiology, of which subjects he was for many years a professor. On several occasions he gave valedictory addresses to the graduating medical students of Georgetown, who were so impressed by their excellence that they printed them each year in small pamphlet form as tributes of affection to their teacher. As an additional evidence of Antisell's industry and versatility it should be mentioned that he published in 1859 a book on the "Manufacture of Photogenic and Hydrocarbon Oils from Coal."

On the outbreak of the Civil War, Antisell, although promoted on May 3, 1861, to the position of principal examiner in the Patent Office, resigned on September 30 of this year to devote all his energies as physician and surgeon to the care of sick and wounded soldiers. He entered the army as brigade surgeon of volunteers, with the rank of major.

In 1863 he was president of a medical examining board, and post surgeon until August, 1865. He was brevetted lieutenant colonel, United States volunteers, March 13, and honorably mustered out of service October 7, 1865.

Shortly after the close of the war, Antisell was appointed to the office of Chemist of the Department of Agriculture.[5] His reports in this capacity are included in the annual reports of the Commissioner of Agriculture for the years 1866 to 1870, inclusive. In addition to his chemical duties at the Department of Agriculture, Antisell continued his practice of giving lectures before the medical students of Georgetown College, which signified its appreciation of his learning by conferring upon him the honorary degree of Doctor of Philosophy. In 1869–70 he also taught chemistry at the Maryland Agricultural College.



April 28th '71 Hon. Horace Capron, Comr.

Sir: I herewith forward the results of analysis of a swamp muck soil from Onondaga Co. N.Y. sent to this Dept. by Alonzo Collins. It had been dried previous to sending and therefore the amount of water which the soil possessed and is capable of retaining at ordinary temperatures is much greater than in this case when it did not exceed ten per cent. The soil is hard, black in color, & compact in texture, and is highly acid in its nature. It yields in 100 parts

Moisture	10.
Vegetable matter	35.50
Mineral matter	54.50
	100.00

It leaves a light brown ash on being burned owing to the presence of some peroxide of iron. To render this soil valuable as a compost it should be carted out and dried in the open air & well weathered, to destroy its acidity or it may be mixed with one-twentieth of quick lime. The mineral from the box is common salt nearly pure. The water which yields it must be a salt spring.

Respectfully,
Thos. Antisell
Chemist

REPORT OF THOMAS ANTISELL TO COMMISSIONER OF AGRICULTURE CAPRON ON THE RESULTS OF A SOIL ANALYSIS, APRIL 28, 1871

In 1871 Commissioner of Agriculture, General Horace Capron, resigned his position to accept a call by the Japanese Government to head a commission for improving agricultural conditions in that nation, and Antisell accompanied him on this expedition as technologist. He was decorated by the Emperor of Japan with the Order of the Rising Sun and received other honors in recognition of his services. The climate of Japan, however, was injurious to the health of Mrs. Antisell, so he returned after six years to Washington where on May 10, 1877, he was reappointed to the place in the Patent Office that he had resigned in 1861. He remained in this position until ill health obliged him to retire in 1891. In his last years of sickness he was tenderly cared for by his daughters. He died on June 14, 1893, in his seventy-seventh year and was buried in the Congressional Cemetery.

For wide experience in the different fields of chemistry as author, teacher, analyst, explorer, and public official, Antisell was undoubtedly the most distinguished of the three eminent Irish refugee chemists whom we have named. Of notebooks of students who heard his chemical lectures I have as yet discovered no copies, although there are undoubtedly examples of such in existence.

We are fortunate, however, in having one of Antisell's laboratory notebooks, written in his beautiful script and containing a full record of his analytical reports between January 2, 1868, and his resignation on June 30, 1871. Antisell describes in this notebook the analyses of 189 samples of which only 117 can be called agricultural. Sixty samples or about one-third of the total number were minerals, such as pyrites, ores of metals, etc., sent in for the most part by Congressmen to satisfy the curiosity of overcredulous constituents. For many years Government chemists had their time frittered away with such trivialities, "to the detriment of science and the benefit of nobody," as Dr. F. W. Clarke once caustically remarked. Antisell called attention to this evil in his first report for 1866, in which he made the following very pertinent suggestion:

> "The propriety of any department of the government authorizing work to be done for the benefit of private enterprise is questionable, and as there are at all times abundant sources of employment for chemical science in connection with agriculture . . . the work in the laboratory should be confined within its proper sphere of limitation."

This is sound doctrine but several decades had to lapse before the principle here announced was put into effect.

Of the agricultural samples in this notebook that were analyzed by Antisell, 26 were marls, 24 soils, 16 fertilizers, 12 wines and musts, 12 waters, 5 tanning materials, 5 medicinal plants, and a long list consisting of sugar beets, fruits, Indian plants, sugars, peat, and other miscellaneous products. Antisell also did much service work for other departments, such as investigations of cancelling inks for the Post Office and of building stone for the Treasury Department.

In May, 1869, Antisell wrote a long interesting report to Commissioner Capron on the fertilizing value of the mud from the bottom of the old canal which once transported produce from the Potomac along what is now Constitution Avenue to the city market. This canal received much sewage and its muddy deposits were supposed by many to have great fertilizing value. Antisell showed that the wet mud, at the very highest estimate for its content of lime, phosphoric acid, potash, ammonia, and other ingredients, had a manurial value of only 98 cents per ton, which would not pay the farmer for hauling it away. Antisell condemned the canal as a menace to the health of the city because of its highly offensive emanations, which he regarded, in accordance with the old theory of miasms, as "potent causes of disease."

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[5] See picture of Antisell in photograph of staff of U. S. Department of Agriculture about 1867, J. CHEM. EDUC., 6, 2161 (1929.)

The 1939–1940 College Chemistry Testing Program

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YEARLY[1] since 1935 the Committee on Examinations and Tests of the Division of Chemical Education, in conjunction with the Coöperative Test Service of the American Council on Education, has provided an objective examination on general chemistry. When the program was initiated, several tests were constructed, classified according to stated objectives, but it was soon apparent that the General Examination (Test C) met with greatest approval and was more generally useful. Since 1937 only one test has been issued. In Table 1, a summary is presented of the development of this program. Interest in the tests has evidently reached a steady state, since nearly the same number of copies has been distributed in each of the last four years. It is revealing to note that the older forms are still in demand. They have advantages for checking the performance of a class against its predecessors, as well as against the national norms. The norms for the current test do not become available until the summer following the administration of the test. By that time the student has usually passed beyond the control of his instructor. Since the 1939, 1940, and 1941 tests are comparable in form and content, it is possible, by reference to the national percentile scores, to use the tests as parallel measuring instruments.

In 1939 and 1940, two provisional forms of the Coöperative Chemistry Test in Qualitative Analysis were also issued. The committee is planning to issue a separate report on these.

TABLE 1

Coöperative Chemistry Test Distribution by Years

Year	*1935–36*	*1936–37*	*1937–38*	*1938–39*	*1939–40*
Test recommended in program*	7,565	18,734	19,747	19,997	19,409
Total tests distributed—all forms	10,564	25,208	24,100	25,947	25,722
Qualitative Analysis					
Total tests distributed				2,140	2,584

* The form of the Coöperative Chemistry Test for College Students recommended for each program is as follows: 1935–36, Form 1936, Tests I, II, and C; 1936–37, Form 1937, Test C; 1937–38, Form 1938; 1938–39, Form 1939; 1939–40, Form 1940. The form of the Coöperative Chemistry Test in Qualitative Analysis recommended for each program is as follows: 1938–39, Form P; 1939–40, Form Q. For a description of these tests, consult the 1941 Catalog, Coöperative Test Service, 15 Amsterdam Avenue, New York City.

The number of colleges which have administered the College Chemistry Examinations has also remained

TABLE 2

Colleges Participating and Reporting

Year	*Number Participating*	*Number Reporting*	*Per cent Reporting*
1935–36	105	39	37.2%
1936–37	290	162	55.9%
1937–38	275	149	54.2%
1938–39	287	169	58.9%
1939–40	289	180	62.3%

TABLE 3

National Chemistry Percentiles, 1940

(Hand-Scored Booklets)

	Part I Information and Vocabulary	*Part II Problems and Equations*	*Part III Scientific Method*	*Total*
No. Cases	9,433	9,433	9,433	9,433
No. Colleges	167	167	167	167
Mean	35.2	21.4	19.3	75.8
Maximum Score	84	65	73	222
Percentile				
100	80	65	67	195
99	69	54	44	157
98	66	51	41	147
97	63	48	38	140
96	61	47	37	135
95	59	45	36	131
94	58	44	35	128
93	57	43	34	124
92	56	42	33	122
91	55	40	32	119
90	54	39		117
88	52	38	30	113
86	51	36	29	110
84	49	35		107
82	48	34	28	104
80	47	33	27	101
75	44	30	25	94
70	42	28	24	89
65	39	25	22	85
60	37	24	21	81
55	36	22	20	77
50	34	20	19	73
45	32	18	17	69
40	30	17	16	65
35	29	15	15	62
30	27	13	14	58
25	25	11	13	54
20	23	9	11	49
18		[illegible]		47
16	22	8	10	46
14	21	7	9	44
12	20	6		41
10	19	5	8	39
9	18		7	38
8	17	4		37
7		3		35
6	16		6	34
5	15	2	5	32
4	14	1		30
3	13		4	28
2	11	0	3	25
1	9		2	21

These percentiles are based on returns from all colleges whose report sheets were received before July 10, 1940.

The scores listed are the raw scores of students who recorded their answers in the test booklets.

The values in each column are the scores at or below which fall the percentage of the cases indicated in the columns at the left of the table. For example, the bottom entry in the *Total* column shows that a score of 21 or below was made by one per cent of the students included; or that the lowest one per cent of elementary chemistry students achieve total scores of 21 or less, the second lowest one per cent, scores from 22 to 25, etc., and the highest one per cent achieve scores above 157.

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[1] (*a*) "The 1935–36 college chemistry testing program," J. Chem. Educ., **14,** 229 (1937); (*b*) Phelan, "The 1936–1937 college chemistry testing program," *ibid.*, **14,** 587 (1937); (*c*) Reed, "The 1937–1938 college chemistry testing program," *ibid.*, **16,** 184 (1939); (*d*) Martin, "The 1938–1939 college chemistry testing program," *ibid.*, **17,** 70 (1940).

substantially constant in the last four years, but, as shown in Table 2, there has been an increase in the number reporting their scores.

Table 3 gives the 1940 national percentiles for hand-scored examination booklets, based upon the results of 9433 students in the 167 colleges which reported their scores in time for inclusion.

As was pointed out last year,[2] a different set of norms applies to scores secured by the use of separate answer-sheets. On the average, the corresponding score is approximately 5 per cent lower than for hand-scored booklets. The difference may be due to the slightly longer time required by the student to transfer his responses to the separate answer-sheet, or it may be due to less obvious factors. The percentile scores for the College Chemistry Test, Form 1940, based on 1377 machine-scored answer-sheets from 8 colleges, are given in Table 4.

TABLE 4

CONDENSED NATIONAL CHEMISTRY PERCENTILES—1940

For Colleges Using Separate Answer-Sheets

	Part I	*Part II*	*Part III*	*Total*
No. Cases	1,377	1,377	1,377	1,377
No. Colleges	8	8	8	8
Maximum Score	84	65	73	222
Percentile		Raw Scores		
100	75	64	53	172
98	61	52	38	138
93	51	44	31	116
90	48	42	30	111
84	43	37	26	100
80	41	35	25	95
75	39	32	23	89
70	37	30	22	85
60	33	25	20	75
50	29	21	17	68
40	26	17	15	62
30	24	13	13	54
25	23	11	12	51
20	21	10	11	48
16	20	7	10	45
10	18	5	8	37
7	16	3	7	34
2	11	0	4	25

While the use of separate answer-sheets requires reference to a different table of *national* percentile scores, it makes no appreciable change in the *relative* standing of students at a given college, where no great change in the character of the student population may be expected from year to year. Should an instructor wish to compare booklet percentiles with separate answer-sheet percentiles, however, he can not substitute Table 4 for Table 3. There is no guarantee that the differences noted do not represent real variations in ability of the students using the separate answer-sheet; the eight colleges which furnished the data for Table 4 may not be representative of all the types included in Table 3. To emphasize this difficulty, Table 5 has been compiled; it shows the differences in *equivalent scores*.

In column (A) the raw scores of hand-graded booklets are given which correspond to the national percentile ranks indicated in the column at the left; the data are taken from Table 3. In column (B) are given the raw scores for machine-graded answer-sheets which received the *same national percentile rank;* the data are taken from Table 4. Column (C) lists the equivalent raw scores for hand-graded booklets corresponding to the raw machine-graded scores given in column (B). These were obtained by examining by both methods 347 matched pairs of students in a single

TABLE 5

COMPARISON OF EQUIVALENT SCORES (FOR HAND-SCORED BOOKLETS AND MACHINE-SCORED ANSWER-SHEETS) WITH EQUIVALENT SCORES OBTAINED BY USE OF MATCHED PAIRS OF STUDENTS*

Hand-Scored Booklet Percentile	*Raw Scores* (*A*)	*Answer-Sheet Raw Scores* (*B*)	*Hand-Scored Booklet Raw Scores* (*C*)	*Difference in Raw Scores* (*B − C*)	*Apparent Difference in Percentile Rank*
Max.	222	222	222	0	0
100	195	172	182	10	0
98	147	138	149	11	− 2
93	124	116	131	15	− 5
84	107	100	115	15	−10
75	94	89	102	13	−11
60	81	75	86	11	−15
50	73	68	77	9	−10
40	65	62	69	7	−10
25	54	51	56	5	− 5
16	46	45	49	4	− 5
7	35	34	35	1	− 1
2	25	25	25	0	0

* The complete table of equivalent scores may be obtained from the Cooperative Test Service.

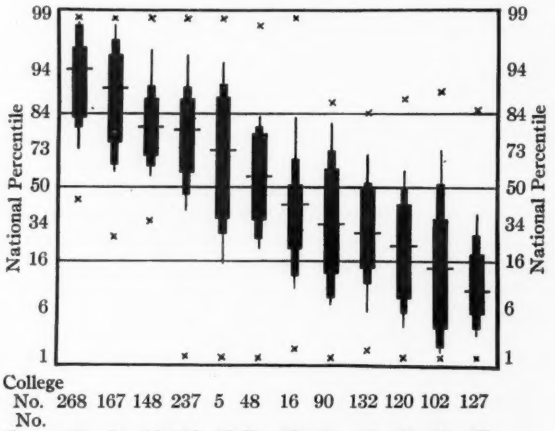

FIGURE 1.—VARIABILITY OF ACHIEVEMENT AS MEASURED BY TOTAL SCORES

Each bar represents an individual college. The wide portion of each bar represents the range of scores of the middle half in each college. The narrow parts extend to the sixteenth and eighty-fourth percentiles in each college, that is, one standard deviation above and below the mean. The lines at the end extend down to the tenth and up to the ninetieth percentile. The crosses below the bars represent the lowest scores, and those above the highest scores in the several colleges. The short cross line at the middle of each bar represents the median score of the college.

The horizontal lines indicate the sixteenth, fiftieth, and eighty-fourth percentiles, that is, the median and one standard deviation below and above the median in terms of scores of the national group. While this chart is based entirely on percentiles, the scale has been altered to correspond roughly to a sigma scale, so that vertical distances are approximately comparable.

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[2] Ref. 1*d*, Table 3; *cf.* MARTIN AND ALLEN, J. CHEM. EDUC., **17**, 75 (1940).

TABLE 6

CONDENSED PERCENTILES CORRESPONDING TO TOTAL RAW SCORES FOR VARIOUS SPECIAL GROUPS

Coöperative Chemistry Test, Form 1940

	Sex Differences		*Effect of High-School Chemistry*		*Type of College*							
	Men	*Women*	*High-School Chemistry*	*No High-School Chemistry*	*Men's Liberal Arts*	*Women's Liberal Arts*	*Coeducational Liberal Arts*	*Teachers College*	*Agricultural and Technical College*	*Engineering College*	*Junior College*	
No. cases	6390	3043	6520	2779	832	1142	4300	562	191	873	1493	
Percentile												Percentile
100	195	191	195	191	187	174	195	151	154	182	181	100
98	153	130	151	132	155	128	147	129	136	159	143	98
93	130	109	129	108	138	104	124	116	118	137	120	93
90	122	102	122	101	131	96	117	111	115	132	111	90
84	112	90	112	90	119	86	106	103	105	119	100	84
80	106	85	106	84	112	82	101	95	103	115	92	80
75	100	81	100	79	106	77	95	89	100	109	87	75
70	95	76	95	75	99	73	90	84	97	105	83	70
60	86	69	86	68	91	66	82	73	90	96	74	60
50	79	61	79	60	83	60	75	67	81	87	67	50
40	71	55	71	53	75	53	67	61	73	80	60	40
30	63	48	64	46	68	46	59	53	63	71	53	30
25	60	44	60	43	64	43	55	49	60	67	49	25
20	55	41	55	40	61	40	51	46	57	62	45	20
16	51	38	52	37	57	37	47	41	53	59	42	16
10	44	33	45	32	49	33	41	35	47	51	35	10
7	40	30	41	29	44	31	37	30	44	46	31	7
2	28	21	30	20	33	21	25	21	32	31	21	2
0	9	8	9	8	23	8	8	14	26	9	9	0

large middlewestern university. In the fifth column the differences in the raw scores are given and in the last column the error which would result if the percentile scores for machine-graded booklets corresponding to (B) were read directly from Table 3, which includes only hand-scored data. The greatest difference in raw score does not correspond to the greatest drop in apparent percentile rank. The average student seems to fare worse than either his more brilliant or inferior classmates. It seems well established that only by use of the matched pair method is it possible to prepare reliable tables of equivalent scores.

Figure 1 shows graphically the variability of achievement at twelve selected colleges. The usual distribution of scores is exhibited.

Table 6 shows the effects of several factors upon the scores; sex differences, previous training, and the type of college attended. The results on the Coöperative Chemistry Test, Form 1940, do not vary appreciably from those recorded in previous reports. On the average, as indicated by the 50 percentile scores, men students obtain higher scores than women; those who have studied high-school chemistry are more competent; students in engineering schools are best prepared for this test, and students in women's colleges do least well.

The variation in scores as affected by hours of attendance in the laboratory, hours of lecture, and the course credit hours, is summarized in Table 7.

TABLE 7

MEAN PERCENTILE SCORE FOR VARYING CLASS ARRANGEMENTS

Credit hours per semester			*Lecture hours per week*			*Laboratory hours per week*		
No.	*Students*	*Percentile*	*No.*	*Students*	*Percentile*	*No.*	*Students*	*Percentile*
3	1427	45	2	1925	44	2	616	35
4	5772	55	3	6842	55	3	3301	58
5	1881	56	4	524	69	4	3393	46
6	103	38	5	43	26	5	279	66
						6	1524	64

In Table 8 the mean scores on the Chemistry Test are compared with professional goals. Students who, as freshmen, believe they will become college teachers, may have some basis for their confidence, as they have again taken first place. Engineering students are once more in second place. Except for home economics majors, who again have made the poorest showing, the rest are grouped around the 50 percentile score.

TABLE 8

MEAN SCORES ON THE CHEMISTRY TEST FOR STUDENTS WITH VARIOUS PROFESSIONAL GOALS

Coöperative Chemistry Test, Form 1940

Professional Goal	*N*	*Total Raw Score*	*National Percentile*
College Teaching	327	98.7	78
Engineering	2,006	87.5	68
Law	125	79.3	58
High-School Teaching	474	78.4	57
Medicine	1,585	77.8	56
Government Service	157	72.9	50
Uncertain	1,374	72.9	50
Miscellaneous	1,600	72.5	49
Journalism	76	69.9	46
Business	426	66.3	42
Agriculture	275	65.3	40
Home Economics	820	56.1	28

These results do not necessarily indicate that students of home economics are less intelligent than the other groups; it merely shows less adequate preparation for this particular examination and may reflect only a different emphasis in the content of the course they pursue. These results are, furthermore, not without ambiguity, as many students are uncertain in their freshman year as to their field of concentration, and many have difficulty in recognizing their field of major interest among the eleven choices given. It is strange that those who plan to become professional chemists are provided with no opportunity to indicate their ambition on the examination booklet.

INSTITUTIONS WHICH USE THE TESTS

Inspection of the list of schools which participated in the 1940 College Chemistry Program indicates that the examinations are of greatest use to the smaller colleges and universities. To the extent that information was available, the colleges which participated have been classified as to type and size. The results are given in Table 9. The nation-wide character of the testing program is demonstrated by the summary of geographical distribution of the colleges given in Table 10.

TABLE 9

CLASSIFICATION OF COLLEGES AND UNIVERSITIES BY SIZE AND TYPE

	Colleges participating in Chemistry Program		*Colleges in United States*	
No. of Students	*Number*	*Per cent*	*Number*	*Per cent*
500 or fewer	147	65.9	368	50.2
500–1000	30	13.4	171	23.3
1000–2000	28	12.6	78	10.6
Over 2000	18	8.1	117	15.9
Total	223	100.0	734	100.0
Type of College				
Junior college	45	15.8	495	33.4
Teachers college	16	5.6	181	13.2
Colleges and Universities	223	78.6	734	53.4
Total	284	100.0	1410	100.0

TABLE 10

GEOGRAPHICAL LOCATION OF PARTICIPATING COLLEGES

North Atlantic States	59
South Atlantic States	29
North Central States	116
South Central States	45
Rocky Mountain States	11
Pacific States	23
	284

Members of the departments of chemistry of only a very few of the larger, nationally famous institutions of higher learning have become interested in the testing program. It is impossible, of course, to analyze the motives which induce instructors in small colleges to utilize the Coöperative Test to such a disproportionate extent. It may be that in small isolated schools chemistry teachers have greater difficulty in setting objective standards for their classes and may turn to such tests as guides. If this is the case, it is still more unfortunate that teachers in more of the larger schools do not also participate so that the norms would constitute a still more reliable guide for those who have no other way of "seeing how they are doing." It is possible, furthermore, that in the larger universities the teachers are expected to devote more of their time to "pure research" rather than to educational problems, and are unaware of the advantages of obtaining an independent check on the performance of their students.

METHOD OF TEST CONSTRUCTION

In the years that have intervened since the Committee on Tests and Examinations was first appointed, a program for constructing the tests has been worked out which will undoubtedly be of interest to those who have used the tests. It is a common error to underestimate the difficulty of selecting valid test items and assembling them into an accurate instrument for measuring attainment.[3] Only by the coöperation of literally hundreds of individuals has it been possible to bring the tests to their present satisfactory state. The development of Form 1940 illustrates the elaborate procedure which is required.

The authors who write the test items make a rather extensive survey of the areas covered in general chemistry, and from each of these fields topics are selected upon which the test items are based. An analysis of the 1938 and 1939 Forms shows all the topics which have recently been covered and an effort is made to avoid excessive duplication.

The test is comprised of six sub-tests and care is exercised to avoid including items from a single area in more than one of these. The task of question-item construction in each of the six sub-tests is assigned to an author who is responsible for that particular part. The collected items constitute the first draft of the test.

The first draft is criticized by the test editors of the Coöperative Test Service, who rewrite and reformulate the items. These are surveyed by subject-matter critics. A second draft is made up and sent to a selected group of at least twenty or more chemistry teachers equitably distributed as to geographical location and type of institution in which they are working. When their criticisms have been received, the questions are again rewritten and, in the third draft, are arranged in a form similar to that of the finished test.

The third draft is sent to the Coöperative Test Service for minor re-editing. A sufficient number of copies of the "Experimental Form" are printed to be used at the end of the first semester (1940) at selected schools so as to measure the difficulty and validity of each item. At the same time, the "Experimental Form" is sent for criticism to 30 or 40 additional chemistry teachers scattered widely over the United States. When the returns are in, the "final form" is assembled. The oversized preliminary form is reduced and no items are used that do not have the desired validity. The items in each sub-test are arranged approximately in order of difficulty, with the easiest coming first. The result is a test which obviously may be used with greater confidence in education measurements than one prepared by a single individual.

USE OF THE COÖPERATIVE CHEMISTRY TESTS

In addition to reviewing the uses which have been suggested in previous reports and elsewhere,[4] chemistry teachers will do well to study the report of the National College Physics Testing Program, 1933–1939, which appeared last year.[5] In some ways the program of the physics teachers has been more ambitious than that of

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[3] FRUTCHEY AND HENDRICKS, "Constructing and validating examinations," J. CHEM. EDUC., **15**, 40 (1938).

[4] (*a*) HENDRICKS AND FRUTCHEY, "Uses of examinations," J. CHEM. EDUC., **15**, 237 (1938); (*b*) MACPHAIL AND FOSTER, "Placement in beginning chemistry courses at Brown University," *ibid.*, **16**, 270 (1939); (*c*) CLARK, "Effect of the nature of the course on achievement in first-year college chemistry," *ibid.*, **16**, 510 (1939).

[5] *Am. J. Phys.*, **8**, 173–81 (June, 1940).

the chemists. Standardized pre- and post-tests in mechanics, heat, sound, light, electricity, and modern physics have been made available which permit testing immediately before and after the topic has been discussed. This continual testing of the student's progress is obviously of more advantage to him than a single check-up near the end of his course, and is mentioned as a possible direction for the Committee's efforts after the completion of the 1941 program.

CORRELATION STUDIES

In last year's report,[6] the scores of 1849 students were correlated with their instructors' independent estimates of their performance in their respective chemistry courses. The overall correlation coefficient, 0.80, is very satisfactory. As there is no reason to suppose that there would be any significant difference this year, this correlation was not repeated. The correlation with the scores on the Psychological Examination of the American Council on Education in the 1939 Report, on the other hand, was too condensed to permit interpretation. This year a more elaborate study was undertaken. Data on 1269 students were graciously supplied by ten colleges which differed widely in geographical distribution and character. As shown in Table 11, correlation coefficients have been computed between the scores on the three parts of the chemistry test with both the Q and L scores on the A.C.E test.[7]

TABLE 11

CORRELATIONS OF SCORES ON THE COÖPERATIVE CHEMISTRY TEST, FORM 1940, AND THE Q AND L SCORES ON THE A.C.E. PSYCHOLOGICAL EXAMINATION*

	Maximum† Correlation Coefficient	*Minimum† Correlation Coefficient*	*Average‡ Correlation Coefficient*
Part I—Q Score	0.355	0.169	0.277
Part II—Q Score	0.476	0.204	0.314
Part III—Q Score	0.483	0.112	0.365
Chem. Total—Q Score	0.531	0.291	0.408
Part I—L Score	0.642	0.288	0.435
Part II—L Score	0.333	0.061	0.198
Part III—L Score	0.488	0.274	0.368
Chem. Total—L Score	0.604	0.413	0.424

* Data from 10 colleges, totaling 1269 cases.
† Coefficients represent values for individual colleges.
‡ Average coefficients are calculated on massed data, not by averaging coefficients for separate colleges.

Inspection of the average coefficients reveals that the scores on Part I (Information and Vocabulary) have the expected higher correlation with the L scores, $r = 0.435$, than with the Q scores, $r = 0.277$, as verbal factors predominate; Part II (Problems and Equations) has a significantly higher correlation with the Q scores, $r = 0.314$, than with the L scores, $r = 0.198$, which is also in accord with expectation. Part III (Scientific Principles) correlates equally well with Q and L scores, 0.365 and 0.368, respectively. This suggests that Part III is just as dependent on verbal factors as upon quantitative reasoning. The correlations of the total chemistry scores with the Q and L scores, 0.408 and 0.424, are as high as is usually found between a general intelligence test and a test of specialized ability.

TABLE 12

INTERCORRELATIONS ON THE COÖPERATIVE CHEMISTRY TEST, FORM 1940,* COMPARED WITH THOSE ON FORM 1939†

	Information and Vocabulary Part I	*Problems and Equations Part II*		*Scientific Method Part III*		*Total Chem.*	
		1939	1940	1939	1940	1939	1940
Part I	..	0.59	0.42	0.64	0.51	0.88	0.82
Part II	..	..	..	0.55	0.38	0.86	0.80
Part III	..	..	..	..	..	0.82	0.74

* No. = 1,492 cases, from 10 colleges.
† No. = 2,407 cases.

The coefficients for the intercorrelations between the scores on three separate parts of the chemistry test with each other, as well as with the total scores, are given in Table 12 for both Form 1939 and Form 1940. The intercorrelations for Form 1940 are uniformly lower; this does not mean, however, that this examination is inferior to last year's, but may indicate the contrary. One may conclude that Parts I, II, and III measure *different aspects* of a student's training to a *higher* extent than on Form 1939, or that the scores on the three sections are not a measure of the *same* quality to so great an extent. The high correlation of the separate parts with the total score is somewhat spurious since the part scores are necessarily included in the total.

WHAT DOES PART III MEASURE?

In Part III, the least conventional section of the tests, the attempt is made to measure *Application of Principles*[8] and *Interpretation of Data.* These are grouped under the general title, *Scientific Method.* Table 13 shows the proportion of the printed space and of the student's time which is devoted to Part III, and compares the scores of Part I and Part II taken together, with the score for Part III for students of various attainments.

Seventy-four per cent of the student's score is obtained in the first 47 minutes and twenty-five per cent in the last 43 minutes. The section devoted to the

TABLE 13

COMPARISON OF PARTS I AND II WITH PART III

	Sum (I and II)		*Part III*	
Pages of Test	*6*		*7*	
Time Allotted	*47 min.*		*43 min.*	
Percentile Score	*Av. Raw Score*	*% of Total Score*	*Av. Raw Score*	*% of Total Score*
99 Percentile	123	73.7%	44	26.3%
75 Percentile	74	74.7%	25	25.3%
50 Percentile	54	74.0%	19	26.0%
25 Percentile	36	73.5%	13	26.5%
10 Percentile	24	75.0%	8	25.0%
		Av. 74.1%		Av. 25.9%

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[6] Ref. 1*d*, Table 7.

[7] According to the 1939 Manual for the A.C.E. Psychological Examination, the two scores "represent two groups of abilities significant for college curricula that are dominantly *linguistic* or *technical.*" Q refers to the Quantitative Test, which includes arithmetical reasoning, figure analysis, and number series questions; and L refers to the Linguistic Test, which contains completion, verbal analysis, and same-opposite type questions.

[8] HENDRICKS, TYLER, AND FRUTCHEY, "Testing ability to apply chemical principles," J. CHEM. EDUC., **11**, 611 (1934).

"Scientific Method," thus, takes over half of the space, nearly half of the time, but contributes only a quarter of the student's final score, no matter whether he is in a high or low percentile group.

The question may reasonably be asked whether Part III scores are a measure of the student's attainment in the use of the Scientific Method. Ashford and Shanner[9] have concluded that while students may be able to discriminate between true and false statements, they do have difficulty in deciding whether a given statement has a great deal, or a little or no bearing upon a given principle; and that increased training does not help them to distinguish between experimental and theoretical statements, if the statements are not obvious. Can Part III be used to measure these more subtle desiderata of a chemistry course? At this time it is difficult to determine. Part III obviously measures something which is characteristic of able students rather than of inferior ones, but is it masquerading under false colors?

Referring again to Table 12, the intercorrelation between Parts I and III has a much higher[10] coefficient, 0.51, than between Parts II and III, 0.38, whereas one might expect the reverse. If the correlations with the A.C.E. Psychological Examination (Table 11) have any significance, this may mean that Part III is more strongly dependent upon *verbal* factors than intended by the authors of the test. Surely if Part III is to continue to constitute half the test, it should be demonstrated more conclusively that it is uncovering some characteristic of the student's mind not divulged more simply and more surely by other devices.

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[9] ASHFORD AND SHANNER, "Are we teaching our students to distinguish between fact and theory?", J. CHEM. EDUC., **17,** 306 (July, 1940).

[10] The critical ratio, $\frac{diff.(r_1 - r_2)}{\text{P. E.}_{diff.}} = \frac{0.13}{0.024} = 5.4$. This means that the difference between the two coefficients, $0.51 - 0.38 = 0.13$, is 5.4 times as large as its own probable error, which is significant.

A Simple Method of Building Close-Packed Molecular and Crystal Models

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MODELS of molecular or crystal structures are becoming increasingly important for a better understanding of the correlation between chemical, mineralogical, and X-ray diffraction data. It is easier to understand a tridimensional structure by studying it as such rather than trying to form a mental picture of the third dimension, based on a two-dimensional drawing. Such models materially assist the student to visualize intricate molecular and crystal structures, and permit him to understand the fundamental reasons for the coherence of these structures much better than does the old way of writing chemical formulas. The research worker, too, will benefit tremendously from constructing such models. In many cases in which the results obtained by X-ray diffraction permit several possible configurations, the construction of models built to accurate proportions might demonstrate that only one of them could result in a structure consistent with the other data available.

In principle we have to distinguish between two types of models: those which I plan to call "expanded" and those best described as "close-packed" models. The former disregard the distances actually existing between the atoms but maintain in some cases the right proportions between the different atomic diameters involved, and most generally retain the correct angles between the locations of the different atoms. Although a considerable amount of valuable information can be derived from such models, especially when cases of rotation and the like must be taken into account, they will always give us a distorted picture of the actual structure and thereby frequently lead to confusion or even to erroneous interpretations.

On the other hand the close-packed model should represent a true magnified copy of the actual structure in every respect.

Comparatively few people build such models, probably because of the lack of accurate jigs and machinery to drill the holes for pegs in the balls representing the atoms. Not only is this procedure time-consuming and tedious, but it is practically impossible to obtain wooden balls (these are most widely used) of perfect spherical shape.

Undoubtedly for these reasons, even experts in the field of structural chemistry or physics are reluctant to build models as they collect new data, preferring to wait until all information has been assembled. The average student rarely has a chance to build models to facilitate his studies.

All these difficulties could be eliminated by a simple, quick, and inexpensive method, which would also give every high-school science teacher an opportunity to explain to his students in a simple but illustrative and up-to-date manner how matter is really built up.

The new method which I am about to describe has already proved its pedagogic value as well as its advantages to the research worker. It consists of coating the balls with unvulcanized rubber, which will stick only to itself. This means that balls so coated may be wrapped in paper or laid on a table without sticking, but if two are tightly pressed together they will cohere.

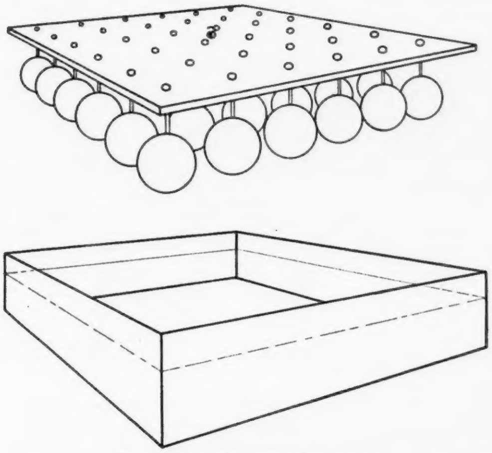

Figure 1.—Dipping Assembly

The top part of the drawing gives a schematic view of a number of cork balls placed on the points of nails inserted in a piece of plywood. The bottom part represents the dipping pan into which the board with the balls is lowered.

The balls to be used can be made from a variety of materials, such as wood, glass, metal, plastics (solid or hollow), rubber (solid, hollow, or spongy), cork, etc. I have found that pressed cork balls are most satisfactory due to their very low density, perfect spherical shape, and rapidity of drying.

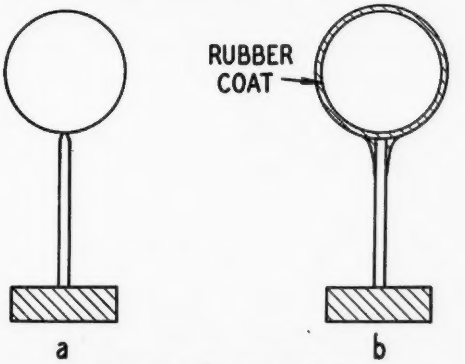

Figure 2.—Coating of Balls

(*a*) represents an uncoated ball mounted on the point of a nail. (*b*) represents the same ball after coating. Note the small amount of rubber which has flowed down the nail, which on pulling the ball off must be cut just above the point of the nail

Balls representing the proportionate dimensions of the atoms involved are placed on a board spiked with needles or thin, sharp-pointed nails. This board is then dipped into a tray containing the dipping solution (Figure 1). To obtain the desired color and the rubber coat we can proceed by either of the two following ways, depending upon facilities and individual preference:

(*a*) The balls are dipped into a quick-drying, water-insoluble paint or varnish. The board is withdrawn, excess paint shaken off, and the balls are allowed to dry, standing upright. If one coat should have insufficient covering power the dipping can be repeated. When the final color coat has thus been applied and dried the balls are dipped into rubber latex of 60 per cent concentration, preferably obtained by centrifuging.[1] To obtain maximum thickness of the rubber coat the balls should be withdrawn slowly from the latex bath. The coat dries in a few minutes at room temperature. It is advisable to dip at least three times into the latex to obtain a coat of sufficient thickness, for the rigidity of the complete model depends considerably on the coherence of the rubber layer. It also permits repeated pulling apart of balls which have been stuck together without ripping off the rubber, which will result if too thin a layer is applied. A ball before and after coating is shown in Figure 2.

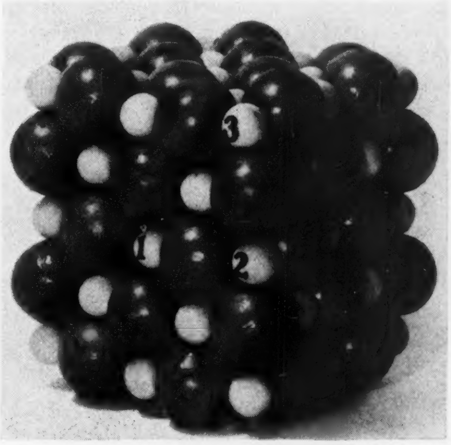

Figure 3.—Silver Bromide Crystal Structure

This model was built simply by pressing appropriate rubber-coated balls together in lines of 5, then uniting 5 such lines to form one plane, making 5 such planes, and sticking these 5 planes together

(*b*) Those who are familiar with the preparation of latex compounds and have the necessary facilities can eliminate the paint coat and dip immediately into an appropriately colored latex compound.

Also one may use a vulcanizable latex compound and vulcanize the rubber by placing the *completed* model for a sufficient length of time in an oven at elevated temperature. However, this is not recommended unless the model is built shortly after the balls have been coated, since the rubber may vulcanize upon standing and lose its tack forever. For the same reason it seems inadvisable to use a latex which has been prevulcanized to its maximum.

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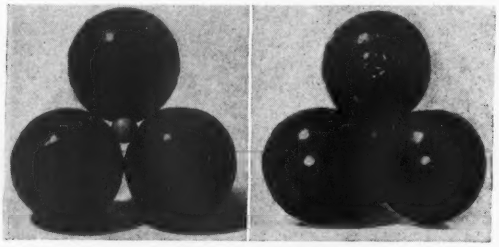
[1] 60 per cent centifuged, ammonia-preserved latex is readily available on the market.

After the final coat has dried the ball is pulled off the needle with a quick jerk. If latex has run down the needle during dipping and should adhere to it very tenaciously (see Figure 2*b*) the strip which still connects the ball with the needle after it has been pulled off should be cut with sharp scissors just above the needle point. The unvulcanized rubber will fuse together at the cut and no sign of this operation will be visible.

The method generally used for egg packaging is most satisfactory for the storage of a great number of coated balls up to a size of one and one-half inches in diameter.

Balls prepared according to procedure (*a*) or (*b*) will lose their tack after some time, especially if handled too much. However, the necessary tackiness can be restored by wiping the coated balls with a cloth soaked in benzene or any other rubber solvent.

If the close-packed model to be constructed does not involve complicated irregular geometric forms, it can be built up simply by sticking the appropriate balls together in a straight line as in a sodium chloride or silver bromide crystal (Figure 3); or in tetrahedral configuration, as for example when building a single silicon tetrahedron (Figure 4); or a tetrahedral chain, as in sodium silicate (Figure 5). All that is needed is a slight pressure when sticking the balls together. If adjustment or rearrangement of the balls is necessary they may easily be pulled off by a quick jerk and replaced, without destroying the coat.



(*a*) (*b*)

FIGURE 4.—THE BUILDING OF A SILICON TETRAHEDRON

(*a*) shows 3 oxygen atoms stuck together in triangular fashion, and the silicon atom placed in the cavity formed thereby. (*b*) shows the tetrahedron completed by sticking the fourth oxygen on top of the silicon as shown in (*a*) so that it touches the 3 oxygen atoms already united

Whenever crystal models are to be built, which for purposes of demonstration should part at certain planes, the model is built in two parts and the surfaces to be separated are dusted with talc, ground mica, starch, or the like, to take away the surface tack.

When models of highly complicated geometrical configurations are to be built angle jigs cannot be avoided. However, instead of boring holes in the balls to indicate the proper angles, it is sufficient to place the ball in the jig and mark the right angles by inserting an indelible lead through the jig holes and marking the surface of the ball. Whenever unusual angles of crystal faces have to be carefully observed, for example in mono- or triclinic systems, the use of a simple angle pattern is advisable.

If completed larger-sized close-packed models are intended for demonstration to a large audience, possibly involving showing them from various sides, it is advantageous to mount them on a thin sheet of glass or transparent, colorless plastic such as "Lucite" or "Plexiglass." This can be done by pouring 60 per cent latex onto the glass or plastic and allowing this coat to dry. The dried coat, which is transparent, is wiped with a cloth soaked with benzene to produce maximum tack. The surface of the model to be placed on the support is treated in the same way and then the entire model is lightly pressed on the glass or plastic. The model may be turned upside down without danger of its falling off, and one may demonstrate its intricate structure from all sides. (Figure 6.)

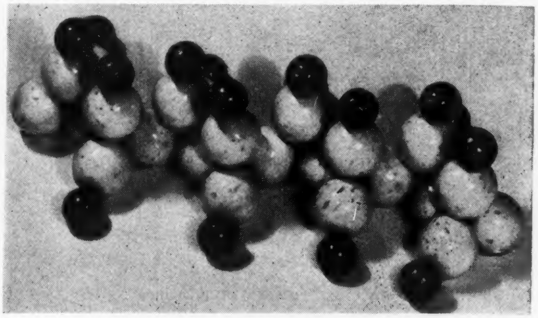


FIGURE 5.—SODIUM SILICATE CHAIN

This model shows the combination of the individual tetrahedra joined together by sharing one oxygen. The black balls represent the sodium atoms. It is clearly evident from the picture that 2 sodium atoms are needed for the saturation of every tetrahedron

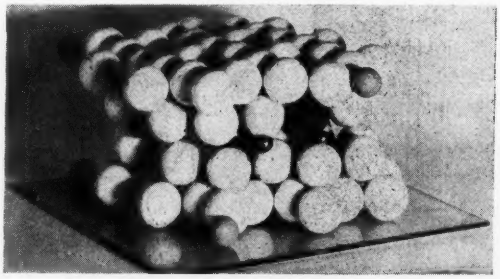


FIGURE 6.—MONTMORILLONITE CRYSTAL

Shows how a completed model of a single montmorillonite crystallite is firmly secured to a latex-coated glass plate. The white balls represent oxygen; the black, hydroxyl; the small metallic balls, aluminum; and the small gray balls on the edges, adsorbed sodium

Since the amounts of paint or latex needed for the coating are small and these products are readily available, the method is not only simple and quick but also inexpensive in comparison with those now available.

A Simple Pressure Filter

A. WEXLER *L.C.C. Hackney Technical Institute, London, England*

IN RESPONSE to a sudden demand in this laboratory for large numbers of pressure filters at very low cost, the form described was designed. The essential feature of interest is the use of a bed of chips of broken glass or porcelain to support the asbestos fiber, instead of a perforated plate as is used, for instance, in the Gooch crucible. This scheme has in fact proved rather more versatile in application than was originally expected, and it is therefore hoped that the forms shown in the accompanying diagrams may prove of some use to chemists, and may also suggest other variations.

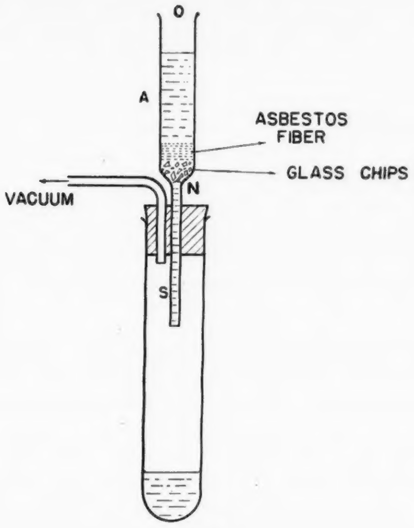


FIGURE 1

Figure 1 shows the simple type of pressure filter for use with the exhaust pump. The tube *A* is readily made by drawing out glass tubing or a test tube, preferably of resistance glass. One or two larger pieces of glass are first lodged in the neck *N* and enough smaller stuff is then added to make a level bed. The prepared asbestos pulp is then added in a thin stream in a quantity suited to the nature of the precipitate to be filtered, and the filter is well flushed in the usual way until the filtrate is clear of fibers.

Dimensions can of course be varied in accordance with requirements. Filters of this type, weighing about one gram, and useful for micro work, can be readily made from thin-walled tubing of approximately $^3/_8$-inch diameter. For general use, stouter tubes $^3/_4$ inch or more in diameter will be found more suitable.

Certain advantages of this simple device, perhaps not immediately obvious, are:

(1) The filter can be made in the laboratory in a few minutes, and the cost is so small that large numbers can be held in stock fully prepared and dried, and also tared if necessary.

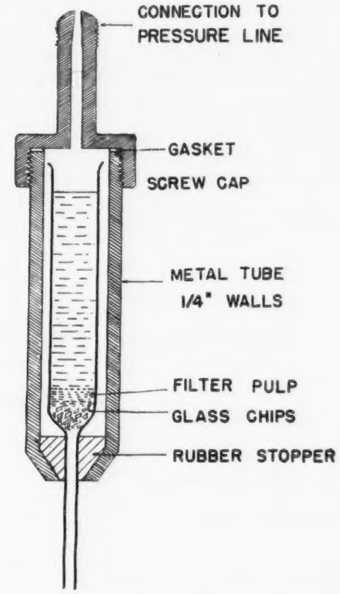


FIGURE 2

(2) The filter requires no special funnel for support, as does the Gooch crucible.

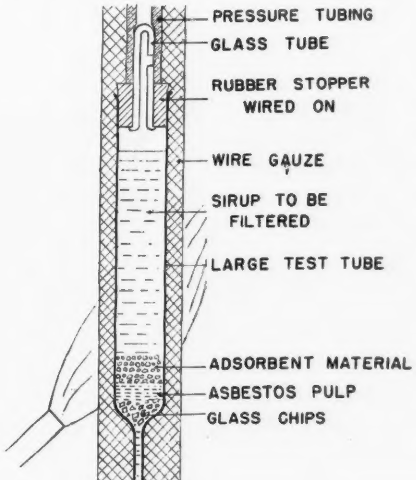


FIGURE 3

(3) Vacuum drying of the precipitate may be very easily effected by making a connection directly to the pump via the stem *S*, closing the opening *O* with a stopper, and gently warming.

(4) Because of the shape of the apparatus, it is easy to arrange for heating the precipitate in a current of a gas. (*Example:* Gravimetric estimation of a mixture of two halides by weighing the silver salts together and then finding the weight of the silver after reduction with hydrogen.)

By using a high-resistance glass, sufficiently high temperatures for ignition, for most purposes, can be safely applied. Good results were obtained, for instance, with Fe and Al precipitates.

Occasions arise in which pressures much higher than fifteen pounds per square inch are needed for the filtration and in which the quantities are too small to put through the laboratory plate filter press. Figures 2 and 3 indicate two different schemes for achieving high-pressure filtration. In using the arrangement indicated in Figure 2 it is essential to have a reliable reducing valve from the gas cylinder, and also a pressure release valve and connection to the filter must be made with high-pressure tubing and screw-on nipples. In the arrangement shown in Figure 3 the pressure is generated internally by careful application of heat to the tube via the roll of wire gauze in which it is wrapped. Due care and judgment are necessary in the use of this device, in view of the contingency of the blow-off valve failing to function. The writer, who has used this device with some success for filtering thick sirups mixed with adsorbents, has been in the habit of operating with the tube well back of the fume chamber, with the window almost closed for protection.

For many purposes paper pulp can be used instead of asbestos.

Lecture Demonstrations in General Chemistry[1]

SAUL B. ARENSON
University of Cincinnati, Cincinnati, Ohio

19. DECOMPOSITION OF POTASSIUM CHLORATE CATALYZED BY MANGANESE DIOXIDE[2]

SETUP as in Figure 13. Heat the $KClO_3$ to above melting. A slow stream of oxygen bubbles rises in the tall cylinder of water. Now remove the flame and twist the tube containing the MnO_2 so that the catalyst dumps into the $KClO_3$. Despite the fact that the $KClO_3$ has cooled down somewhat, a rapid evolution of oxygen occurs in the presence of the MnO_2. The presence of oxygen in the gas space above the water may be demonstrated with a glowing splint.

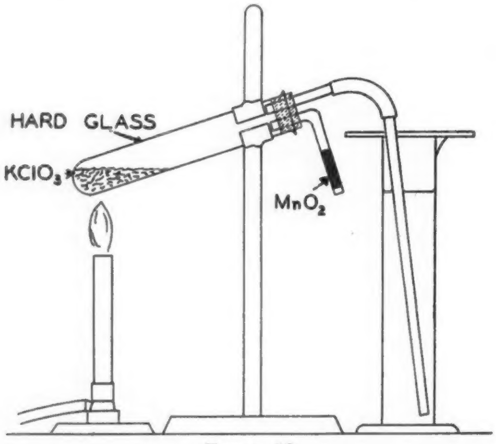


FIGURE 13

A variation is to have two tubes, one containing $KClO_3$, the other $KClO_3$ + MnO_2, leading to two cylinders of water. Lighted burners are thrust simultaneously beneath the two tubes. Evolution of oxygen commences sooner from the catalyzed mixture.

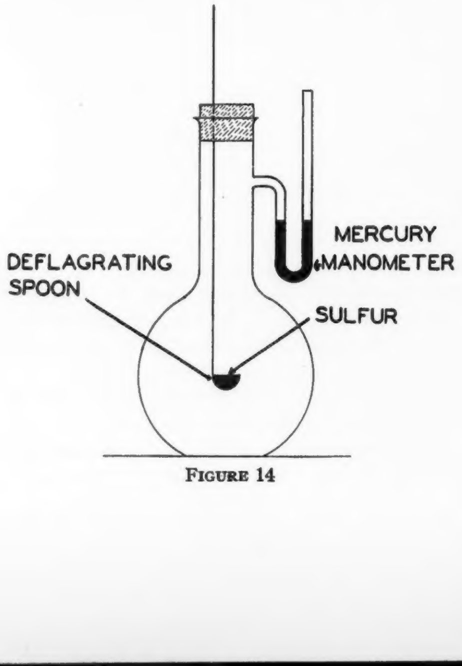


FIGURE 14

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[1] Continued from the November, 1940, issue.

[2] This and the following demonstration were contributed by Hubert N. Alyea, Assistant Professor of Chemistry, Princeton University.

20. GAY-LUSSAC'S LAW OF COMBINING VOLUMES

Setup as in Figure 14. If a one-liter flask is used, and the manometer U-tube set close to the neck, the flask will not topple. Light the sulfur over a burner, and lower into oxygen or air in the flask. When, after a few minutes, the gaseous product has cooled, the mercury levels will be equal. This shows that no change in volume has occurred during reaction; that the reaction is probably

$$S_{solid} + 1 \text{ volume of } O_2 \longrightarrow 1 \text{ volume of } SO_2$$

and that SO_2, not SO_3, is the product of the combustion.

21. THE RESOLUTION OF CARBONATES IN EXCESS CARBON DIOXIDE[3]

An unfrosted light bulb is set up in series with a pair of copper electrodes dipping into 40 cc. of distilled water in a 100-cc. beaker. Upon adding 2 cc. of saturated $Ba(OH)_2$ solution, the lamp shows good conductance. Carbon dioxide is now bubbled through the solution; the light gradually goes out and then comes on again as the soluble bicarbonate is formed. Lime water can also be used, but is not quite as satisfactory because a saturated solution of $CaCO_3$ conducts better than one of $BaCO_3$.

22. THE MOTION OF MOLECULES IN GASES

When steel ball bearings, such as are used in the ordinary bicycle, are dropped upon a porcelain plate, or thick glass disc, the balls bounce up and down interestingly. As a second plate, held horizontally, is lowered against the bouncing balls, they rebound with increasing frequency. This demonstrates the increase in frequency of collision (pressure) upon compressing a gas.

23. EXPLOSIVE RANGE OF GASES[4]

Three gastight tin cans open at one end are needed; Campbell soup cans are satisfactory. Fill the cans (*a*) one-tenth, (*b*) seven-tenths, and (*c*) three-tenths full of hydrogen; and invert them in a trough of water until needed. Then lift them from the water, admitting air, and cover with several thicknesses of filter paper. Poke a hole in the paper and light each can with a taper at the opening.

Cans (*a*) and (*b*), which contain mixtures of air with 10 per cent and 70 per cent hydrogen, respectively (upper and lower explosion limits), explode mildly. Can (*c*), which contains almost an equivalent mixture of hydrogen and oxygen, explodes so violently that it must be kept at arm's length.

24. CHEMICAL KINETICS—REACTION VELOCITY

(*a*) *Effect of Catalysts:*

One of the cans mentioned immediately above should be filled with two parts H_2 and one part O_2. Here as before the can is kept in the trough until needed. It is removed in the same manner, only this time the filter-paper cover is removed and the can is covered with a large cardboard paddle which has a small ball of platinized asbestos suspended from the end. The reaction is almost spontaneous. *Caution:* Stand back—the reaction is very violent.

(*b*) *Effect of Temperature:*

1. Fifty cc. concentrated H_2SO_4 at room temperature are poured into 50 cc. saturated sugar solution.
2. Fifty cc. concentrated H_2SO_4 are poured into 50 cc. saturated sugar solution, after both solutions have been cooled 15°C. below room temperature.

These reactions are carried out simultaneously. Mount on a ring stand side by side. Place large evaporating dishes under the beakers.

25. COLD PHOSPHOROUS FLAME[5]

A few pieces of phosphorus are placed in a dry receiver which is filled with glass wool. The receiver is placed in a water bath and a stream of dry CO_2 is passed through. The phosphorous vapor, carried along with the CO_2, oxidizes in the air; and a green flame results which is so cool that a finger may be held in it.

26. WHY BLUEPRINTS PRINT[6]

Take a block of wood about 6″ × 6″ × 1″, and near each corner drill a hole large enough to support a 6″ × 1″ test tube. In the center of the block mount a photoflood lamp.

Expose the following solutions to this light for 30 seconds: (*a*) ferric chloride, (*b*) ferric chloride plus citric acid or other suitable reducing agent, (*c*) same as preceding tube, but shielded from the light with paper, (*d*) same as preceding tube, but shielded from the light with red cellophane.

Now add potassium ferricyanide to each tube. Tube (*b*) alone gives a test for ferrous iron, indicating that conditions (*a*), (*c*), and (*d*) will not lead to the photoreduction of ferric to ferrous ion. Tube (*d*) shows that red light cannot cause this reaction and suggests why the photographic dark room has a red "safety" light.

Blueprints contain ferric citrate or ferric oxalate, and the iron is photochemically reduced to the ferrous condition. Upon dipping the paper into a solution of potassium ferricyanide developer, ferrous ferricyanide (Turnbull's blue) is formed.

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[3] This and the following demonstration were contributed by A. E. Koenig, Professor of Chemistry, Montana School of Mines.

[4] This and the following demonstration were contributed by J. C. Warner, Head of the Department of Chemistry, Carnegie Institute of Technology.

[5] Contributed by W. E. Caldwell, Assistant Professor of Chemistry, Oregon State College.

[6] Contributed by G. M. Lisk, Northwestern State College, Alva, Oklahoma.

The Founding of the American Chemical Society

WILLIAM F. EHRET

Washington Square College of Arts and Science, New York University, New York City

ALTHOUGH the events leading to the founding of the American Chemical Society have been clearly written down on a number of occasions (*1*, *2*, *3*), most members of the profession have no idea of the time, place, or purpose of formation of the strongest organization of chemists in the world. Particularly is this true of the younger men in our profession and of the students who some day will follow in our footsteps. It seems fitting therefore to recount briefly some of the high points connected with the origin of the society and to add a few which, to the author's knowledge, have never been revealed. These concern the *birthplace* of the society. All the founders were so familiar with this that they did not stop to mention details, consequently the record, up to the present, was not quite clear as to the exact locale in which the founding took place. Fortunately, local directories and histories of the time are still available and it is with the help of these that the writer was able to fix definitely the *place* of origin of the society.

There can be no doubt that the American Chemical Society had its inception in the minds of some of those who gathered for the Centennial celebration at Priestley's home in Northumberland, Pennsylvania, in 1874. It was at this meeting that the matter "of calling a representative committee of chemists of the United States, to form a chemical society" was first brought up. Instead of acting on this proposal the assembled chemists decided to appoint a committee "to coöperate with the American Association for the Advancement of Science to the end of establishing a chemical section on a firmer basis." As an outgrowth of this there was created in the same year a sub-section of chemistry in the A.A.A.S. The sub-section carried on until 1882, when a full section of chemistry was established, and, as is well known, it has continued to be one of the most active and efficient sections of the society.

THE MAIN BUILDING OF THE WASHINGTON SQUARE COLLEGE OF NEW YORK UNIVERSITY WHICH NOW STANDS ON THE SITE OF THE "UNIVERSITY BUILDING"

Even with these strides taken, there were those who felt that the interests of American chemistry would best be served by an independent American chemical society. Nowhere in the country was this want more strongly felt than in the environs of New York and it is therefore not surprising that the next move toward an independently organized body started here. On January 22, 1876, at a meeting in New York City at the home of Professor C. F. Chandler, who occupied the chair of analytical and applied chemistry in the School of Mines of Columbia College, a committee was appointed to attend to the details of founding such an organization. A circular was drawn up and sent to a hundred chemists in New York and vicinity. It read:

> "New York, Jan. 22, 1876
>
> "Dear Sir:
>
> "For some time past many chemists of this city and vicinity have felt the want and deplored the absence of an association, such as exists among other professions, which would lead to a better understanding and a closer acquaintance among its members, in which scientific and practical subjects relating to our special science might be discussed, and means devised in the common interest of the profession. Widely scattered as the chemists in this neighborhood are, such an association would become the center of a pleasant personal intercourse, and of an interchange of views, experiences and researches, which would benefit all concerned.
>
> "The undersigned, believing the present an opportune time for establishing a 'Chemical Society' in New York, respectfully invite your coöperation, and would be pleased to receive an early expression of your views upon the subject. As soon as a sufficient number of assenting replies have been received it is proposed to call a meeting for the purpose of forming a permanent organization."

The circular was signed by Chandler, Habirshaw, Endemann, Alsberg, Morton, Walz, Hoffmann, and Casamajor, names that in many other directions as well have left a lasting imprint on the record of American chemistry. Forty affirmative replies came in, and with such a gratifying response the committee decided to extend the scope of the organization to include *all* American chemists. Subsequently a similar circular was sent to chemists in every part of the country whose names and addresses could be learned. Sixty additional adherents to the plan were thus obtained, representing seventeen states and the District of Columbia.

As a result of these encouraging replies the committee sent out the following note which led to the meeting at which the American Chemical Society was founded:

> "New York, March 27, 1876
>
> "Dear Sir:
>
> "A meeting for organizing the American Chemical Society will be held on Thursday evening, April 6, 1876, at 8 o'clock P.M., in the lecture room of the College of Pharmacy, University Building, corner Waverly Place and University Place.
>
> "Your attendance is earnestly requested."

Thirty-five chemists responded, and, with Professor C. F. Chandler in the chair, a motion to proceed with the organization was adopted, as were also a constitution and by-laws. John W. Draper, professor of chemistry at New York University, was elected president of the new society. The first list of members, printed the same year, included 133 names, of which 53 were from New York and vicinity. The story of the steady forward march of the organization since that time has already been well told (*1*, *2*) and is clearly reflected in the constantly mounting membership, now over 25,000.

At first sight the above note would seem to leave little doubt as to the geographical location (see frontispiece)[1] of the point of origin of the society. When, however, the author made inquiries regarding a College of Pharmacy, he found that at no time in the history of New York University has there been such a college directly connected with it. The apparent discrepancy was resolved only after recourse to city directories extending over a period of some forty years both before and after 1876. It turned out that the College of Pharmacy of the City of New York was an independent organization (*4*, *5*) with its own president and faculty, and that it held its meetings and classes in the University Building at this particular period. Professor C. F. Chandler is listed (*5*) as having held, in addition to his assignment at Columbia College, the chair of chemistry in the College of Pharmacy. Such were the humble beginnings of the American Chemical Society. Its thirty-five members met in the lecture room of the College of Pharmacy which apparently rented space from one University and borrowed its professor of chemistry from another!

THE LABORATORY OF PROFESSOR JOHN W. DRAPER, FIRST PRESIDENT OF THE SOCIETY, IN THE UNIVERSITY BUILDING AT THE TIME OF THE FOUNDING OF THE AMERICAN CHEMICAL SOCIETY

Today, surveying the accomplishments during the sixty-four years of its existence, we find that the society has fulfilled completely all the aims laid down by the founders in the prospectus of January 22, 1876. They foresaw clearly certain needs of the profession; time has not changed these nor brought new ones.

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[1] The author is indebted to Professor Herman M. Partridge for the illustrations accompanying this article.

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(1) HALE, *J. Am. Chem. Soc.*, Twenty-fifth Anniversary Supplement, 41 (1902).
(2) BROWNE, *ibid.*, **48**, Golden Jubilee Number, Part I (1926).
(3) BROWNE, *Ind. Eng. Chem.*, **27**, 501 (1935).
(4) "Goulding's New York City directory 1875–76," Lawrence G. Goulding, New York City, **1875**, pp. 34, 250.
(5) "Trow's New York City directory 1876–77," Trow City Directory Co., New York City, **1877**, p. 41.

OBJECTIVE TESTS IN ORGANIC CHEMISTRY

THE 1941–42 series of the Coöperative Objective Tests in Organic Chemistry will be available about the first of July. This series will contain 25 topic examinations of one planographed page each and two semester examinations of two pages each, making a total of 29 pages of testing material.

It is hoped that those who use these tests during the coming school year, 1941–42, will coöperate to the extent that this series may be standardized and the validity of each item determined. Those who desire to avail themselves of machine grading may do so on a cost plus basis.

Sets will be available to instructors, graduate students, or research workers in lots of five or more at 20 cents per set (plus postage) provided the order is received on or before July 1, 1941. Orders for lots of five or more received after that date will be billed at 25 cents per set, whereas all single sets are priced at 35 cents. A key for convenience in grading is furnished with each order.

Orders may be placed with the chairman of the committee, Ed. F. Degering, Department of Chemistry, Purdue University, Lafayette, Indiana. Shipment will be made about August 10.

The Polarographic Method of Analysis

III. Fundamentals of Quantitative Analysis

OTTO H. MÜLLER

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THE rapid growth of interest in the polarographic method has come about since the publication of three fundamental papers which have changed the method from an empirical one to one that is based on well-known physical-chemical concepts. The first of these papers, by Heyrovský,[1] established the necessary conditions for obtaining a current which is a function of the diffusion and therefore proportional to the concentration of the reacting material. The second paper, by Ilkovič,[2] gives a mathematical derivation, supported by experimental proof, of this diffusion current and its dependency on the characteristics of the dropping electrode. These two papers clarified the principles of quantitative polarography while the third paper, by Heyrovský and Ilkovič,[3] did the same for qualitative polarography. In this last paper the half-wave potential was proposed for the characterization of polarographic reductions and oxidations after its theoretical significance for reversible reactions had been pointed out. It is impossible here to outline all the work leading to these developments or to give credit to the many who have contributed. Only the final conclusions can be given, with a few demonstrative experiments carried out with the apparatus described in Part II of this series.[4] For additional information the general references given in the first paper[5] and three fairly complete bibliographies[6] may be consulted.

Quantitative polarography is based on the fact that in a cell consisting of one small, easily polarizable electrode and one large, non-polarizable electrode a complete concentration polarization may be obtained, which results in a limiting current over a range of potential. Within this range any material which reaches the electrode will be electrolyzed immediately, and the current will be determined by the rate of supply of this material from the body of the solution. When this was first observed by Heyrovský, its potentialities for analytical purposes were realized at once, but it took many years of concentrated effort to determine the various factors which influence the limiting current. Today we know four of these factors, the residual current, the adsorption current, the migration current, and the diffusion current, which will be discussed in this paper.

RESIDUAL CURRENT

In the reduction of ions with a strongly negative reduction potential, such as potassium ions, a small current flows before the deposition of the potassium begins. This is observed even when the purest, air-free solutions are used, so that it cannot be due to the reduction of impurities. Furthermore, no sign of a wave is apparent but the current rises approximately proportional to the applied voltage. It must therefore be considered a non-Faradayic or "condenser" current. Because of the continual formation of fresh surface and the removal of the old charged surface as the drops of mercury fall off, the charging current becomes appreciable. As is well known, all metals when submerged in an electrolyte are covered with an electrical double layer of positively and negatively charged ions. The composition of this double layer and thus the charging current varies depending upon the potential which is imposed on the metal.

Experiment 1.—Electrolyze 10 cc. of 0.1 N potassium chloride between zero and 2 volts in steps of 0.1 volt using the galvanometer at full sensitivity up to 1.8 volts. A calomel half-cell connected by agar bridges serves as anode. Remove all atmospheric oxygen by bubbling nitrogen through the solution for 30 minutes.

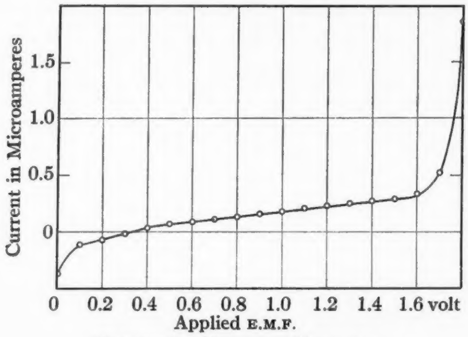

FIGURE 1.—RESIDUAL CURRENT

The data from Experiment 1 are plotted in Figure 1. The current shown here appears in all air-free experiments carried out with the same dropping mercury electrode. Obviously, it must be subtracted from the total current observed during the reduction of some reducible material in order that the actual current used in the reduction may be known. In very dilute solutions neglect of this point may cause a large error. As will be shown later, in practical polarographic work this residual or "condenser" current is automatically subtracted by the proper placement of tangents to the wave.

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[1] *Arhiv za Hemiju i Farmaciju*, **8,** 11 (1934).

[2] *Collection Czechoslov. Chem. Commun.*, **6,** 498 (1934).

[3] *Ibid.*, **7,** 198 (1935).

[4] J. CHEM. EDUC., **18,** 111 (1941).

[5] *Ibid.*, **18,** 65 (1941).

[6] HEYROVSKÝ AND KLUMPAR, *Collection Czechoslov. Chem. Commun.*, **10,** 153 (1938); HEYROVSKÝ, *ibid.*, **11,** 98 and 667 (1939)

ADSORPTION CURRENT

This type of current appears on the polarograms in the form of more or less pronounced maxima. After a rapid increase in current with increasing applied voltage, a more or less abrupt fall in current to a fraction of the peak value occurs. These maxima appear only under special conditions and can be eliminated. They indicate that during part of the current–voltage curve, there is a concentration of the reactive substance in the double layer which is in excess of that in the body of the solution. The stirring effect of the growing drop is considered by some investigators to be responsible for this. On the other hand, Heyrovský, who found that these maxima can be suppressed by surface-active or highly adsorbable substances, assumed that the excess of reactive material at the electrode is due to its adsorption on the fresh surface. Neither of these theories explains adequately the sudden disappearance of these excess concentrations at critical potentials and some other peculiarities pertaining to maxima. Due to the controversial nature of the subject, no detailed discussion of these and other theories is warranted in this paper. However, it is important from an analytical standpoint that maxima can be suppressed by surface-active substances, thus eliminating the undesirable adsorption current.

Experiment 2.—(*a*) Electrolyze, open to air, 10 cc. of 0.001 *N* potassium chloride between zero and 2 volts at intervals of 0.1 volt, using the galvanometer with shunt at position No. 4. A layer of mercury serves as anode. (*b*) Repeat the procedure after adding one drop of 0.01 per cent solution of acid fuchsin.

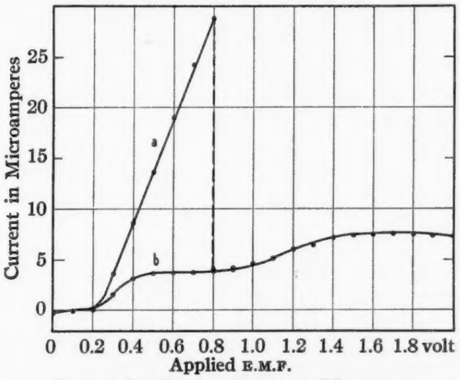

FIGURE 2.—SUPPRESSION OF A MAXIMUM

The results are plotted in Figure 2. It may be seen that one drop of the acid fuchsin sufficed to remove completely the marked oxygen maximum. The first wave of the curve, which is due to the reduction of dissolved oxygen to hydrogen peroxide, is now smooth and easily measured while the second wave, which represents the further reduction to hydroxyl ions, remains unchanged. Many indicators have been found satisfactory for suppressing maxima; alkaloids, organic acids, gelatin, and agar, as well as some detergents, have also been used. While some of these may be reduced themselves at the dropping mercury electrode, they do not interfere in the analysis because they are present in very small concentration only. It has been possible to use the suppressive action of various agents on the oxygen maximum as an indication of the adsorbability of the agent.

MIGRATION CURRENT

If the adsorption current is eliminated by a suppressor and the residual current is accounted for, there remain two major factors for supplying electroactive material to the electrode. One is migration of charged particles in the electric field and the other is diffusion of particles in a gradient produced by the removal of the material at the electrode. Heyrovský showed that the migration current can be practically eliminated if there is added to the solution an "indifferent" electrolyte in a concentration which is at least tenfold that of the reacting material. To define this theoretically, Heyrovský writes:

$$I_l = I_d + I_m \quad \text{(for cation reduction)} \tag{1}$$

and

$$I_l = I_d - I_m \quad \text{(for anion reduction)} \tag{2}$$

where I_l is the total limiting current, I_d the diffusion current, and I_m the migration current. The migration current is equal to that fraction of the total current carried by the electroactive ion:

$$I_m = I_l \times \frac{u}{u + v} \text{ or } I_m = I_l T^+ \tag{3}$$

and

$$I_m = I_l \times \frac{v}{u + v} \text{ or } I_m = I_l T^- \tag{4}$$

where u and v are the mobilities of the cation and anion and T^+ and T^- are the corresponding transference numbers. From this can be found the maximum ratio between diffusion current and limiting current which can be obtained by the addition of an indifferent electrolyte:

$$I_d/I_e = 1 - T^+ \text{ (for cation reduction)} \tag{5}$$

and

$$I_d/I_l = 1 + T^- \text{ (for anion reduction)} \tag{6}$$

Since the transference numbers of most reducible cations are in the neighborhood of 0.5, the limiting current can be decreased to one-half its initial value if sufficient indifferent electrolyte is added. On the other hand, in the reduction of an anion (*e. g.*, IO_3^-) the limiting current can be increased to about one and one-half times the initial value when an indifferent electrolyte is added. While these conclusions are only approximately correct they have been of real value because they brought out the significance of indifferent electrolytes. An indifferent salt is one that conducts the current but does not react with the substance under investigation nor at the electrode in the range of potential that is studied. A variety of indifferent electrolytes have been suggested which are suitable for many analytical procedures. Often they contain in addition the necessary maxima-suppressors and buffer mixtures for maintaining a constant pH. They are called Grundlösungen or supporting electrolytes.

Experiment 3.—Electrolyze, air-free, (*a*) 2 cc. of 0.01 *M* lead chloride plus 8 cc. of water and (*b*) 2 cc. of 0.01 *M* lead chloride plus 8 cc. of 0.1 *N* potassium chloride plus one drop of basic methyl red, between zero and 2 volts at intervals of 0.1 volt. A layer of mercury serves as anode. When the current increases markedly, make the interval in the applied E.M.F. 10 or 20 millivolts. Use the galvanometer with shunt at position No. 4.

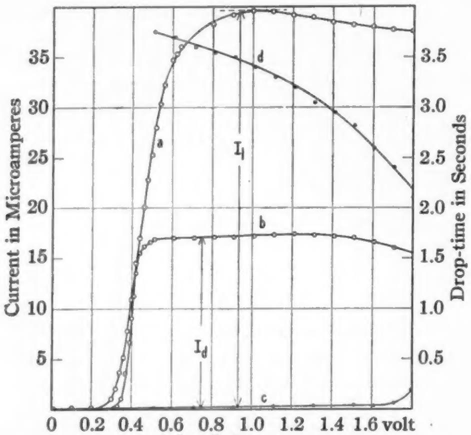

FIGURE 3.—ELIMINATION OF THE MIGRATION CURRENT
Curves *a*, *b*, *c*—Current plotted against applied voltage
Curve *d*—Drop-time plotted against applied voltage

The data of Experiment 3 have been plotted in Figure 3. Since the layer anodes used had potentials which differed from that of a saturated calomel half-cell, 200 millivolts in curve *a* and 90 millivolts in curve *b* were subtracted from the observed applied voltage in the plotting of this graph. Both curves show a decrease in current after 1.0 volt; this is due to the change in surface tension of the mercury which will be discussed in detail later on. The peak of curve *a* and the plateau of curve *b* may be conveniently used for comparing the wave-heights. The residual current taken from Figure 1 is also shown in this Figure 3 as curve *c*. It becomes negligibly small when drawn on this scale. As expected, the limiting current obtained in the presence of an indifferent electrolyte, that is, the diffusion current (I_d), is 44 per cent of the limiting current (I_l) obtained in the absence of an indifferent electrolyte. Similar experiments could be performed with other cations which would all give ratios of I_d/I_l close to 0.5 with the exception of the hydrogen ions which, as might have been expected from the above equation, should give a ratio of about 0.2. In the reduction of anions, the addition of an indifferent electrolyte will produce an increase in the diffusion current because it will eliminate the migration of the anions away from the cathode. Anions suitable for this study are iodate, bromate, selenide, and telluride ions. The diffusion current obtained in the reduction of uncharged particles should be independent of the presence of indifferent electrolytes. The best test of this can be made with oxygen in potassium chloride solutions of different concentrations.

DIFFUSION CURRENT

Once it was clearly established how pure diffusion currents could be obtained, it was possible to analyze more closely the factors which govern the diffusion current. These factors may be divided into two groups: first, those concerned with the diffusion process itself, such as temperature, viscosity, and ionic strength of the solution; and second, those dealing with the formation and size of the electrode surface at which the diffusing material reacts. The first group of factors is generally known and can be found in the chemical literature, but the second group is particular to the polarographic method and must be defined and evaluated. Ilkovič[2] is to be credited with having given the theoretical and experimental proof of an equation which clearly defines these factors and which has been verified theoretically and experimentally by others. The Ilkovič equation, which holds for constant temperature, is:

$$I_d = 0.627 \times nFD^{1/2}\,Cm^{2/3}\,t^{1/6} \qquad (7)$$

in which I_d is the diffusion current, n is the number of electrons involved in the reduction of one molecule of the reducible substance, F is the Faraday, D is the diffusion coefficient of the reducible substance, C its concentration, m the weight of mercury flowing from the capillary per second, and t the time necessary for the formation of one drop of mercury.

The simple apparatus described before[4] is adequate to demonstrate the significance of each term in the Ilkovič equation. Keeping all variables in this equation constant except one, the relation of the diffusion current to each variable is illustrated by the following experiments.

$I_d = Kn$. To test this it is best to use multivalent cations such as chromic and cobaltic ions, which are reducible in two dissimilar steps within the range of the dropping mercury electrode.

Experiment 4.—Electrolyze, air-free, 10 cc. of 0.002 *M* hexamine cobaltic chloride [$Co(NH_3)_6Cl_3$] in 0.1 *N* ammonium chloride between zero and 2 volts in steps of 50 millivolts, using the galvanometer with shunt at position No. 4. A saturated calomel electrode (S.C.E.) serves as anode, and the pressure of mercury is 50 cm.

The results are plotted in curve *a* of Figure 4. Two waves are obtained—the first at about 0.2 volt, the second with a sharp maximum near 1.2 volts. These are due to the reduction of [$Co(NH_3)_6^{+++}$] to [$Co(NH_3)_6^{++}$] and the further reduction of [$Co(NH_3)_6^{++}$] ions to metallic cobalt. For the first reduction only one electron is needed per ion ($n = 1$); for the second reduction two electrons are used ($n = 2$). The height of the first wave is easily measured while the height of the second is complicated by two factors, the maximum and the negative slope of the curve with increasing potential. The suppression of this particular maximum has led to a most promising polarographic research which will be described in a subsequent paper.

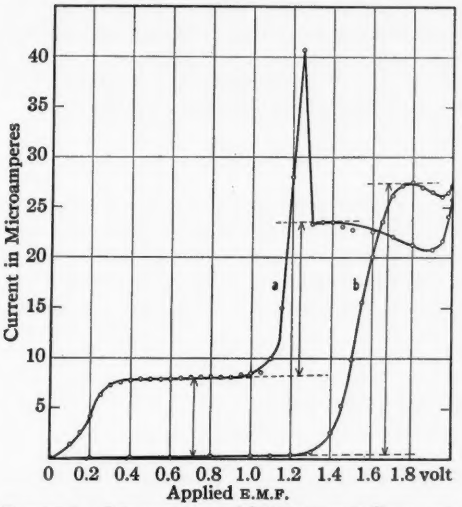

FIGURE 4.—REDUCTION OF (*a*) HEXAMMINE COBALTIC CHLORIDE AND OF (*b*) HYDROGEN IONS*

* *Correction:* All points plotted after the maximum in curve *a* (from 1.2–2.0 volts) should be raised by two microamperes.

The negative slope of this curve is due to the change in surface tension of the mercury and will be discussed below. A measurement may, nevertheless, be made in spite of these difficulties by drawing a line parallel to the limiting current of the first wave through the second limiting current at its highest point following the maximum. It may be noticed that this line is not perfectly horizontal but has a slight positive slope. This demonstrates the automatic correction for the residual current mentioned above. We then get the difference between the first limiting current and the residual current, equal to 8.0 microamperes, as the height of the first wave, and the height of the second wave as the difference between the second limiting current and the extension of the first limiting current, equal to 17.0 microamperes. The ratio of the two wave heights is 2.13, which is near enough to the expected value of 2.0, considering the complexity of the curve.

$I_d = KD^{1/2}$. To make this relationship obvious, it is best to use hydrogen ions, whose diffusion coefficient varies markedly from those of other ions.

Experiment 5.—Electrolyze, air-free, 10 cc. of 0.002 *N* hydrochloric acid in 0.1 *N* potassium chloride under conditions otherwise identical to those in Experiment 4.

The results are plotted as curve *b* in Figure 4. A large single wave near 1.5 volts may be observed. It will be noticed that up to 1.2 volts, only a minute residual current flows. If this current is extrapolated and a line parallel to it is drawn through the highest value of the hydrogen plateau we get the height of the diffusion current, I_d = 26.5 microamperes. Under the same conditions we found 8.0 microamperes for the univalent reduction of $[Co(NH_3)_6{}^{+++}]$ ions in an identical concentration. Thus the ratio

$$I_{d_{H^+}}/I_{d_{Co(NH_3)_6{}^{+++}}} = 3.31$$

If for a first approximation, the diffusion coefficient of the $[Co(NH_3)_6{}^{+++}]$ ion may be assumed to be equal to that of the $Fe(CN)_6{}^{---}$ ion we can calculate the ratio

$$D^{1/2}{}_{H^+}/D^{1/2}{}_{Co(NH_3)_6{}^{+++}} = 9.34^{1/2}/0.89^{1/2} = 3.24$$

which shows satisfactory agreement with the experimental value.

$I_d = KC$. Cadmium sulfate is a convenient salt to use in demonstrating the relationship between diffusion current and concentration because maxima do not interfere.

Experiment 6.—Prepare the following solutions in 0.1 *N* potassium chloride: 2.5×10^{-2}, 1×10^{-2} and 5×10^{-3} *M* cadmium sulfate; dilute each 10, 100, and 1000 fold with 0.1 *N* potassium chloride. Instead of the 5×10^{-6} *M* cadmium sulfate solution substitute pure 0.1 *N* potassium chloride to determine the residual current which must be subtracted from the observed limiting current. Free the solutions from air, use a layer anode and observe the current at a constant applied voltage of 1.0 volt. Note that the diffusion currents at a given concentration remain constant from 0.9 –1.1 volts.

The observed current is plotted against the concentration in Figure 5. Logarithmic scales are necessary because of the thousand fold changes plotted. The relationship between concentration and diffusion current is linear within the experimental error, which is about five per cent. This is the most used relationship for quantitative analyses, because pressure, drop-time, capillary, and temperature are usually kept constant.

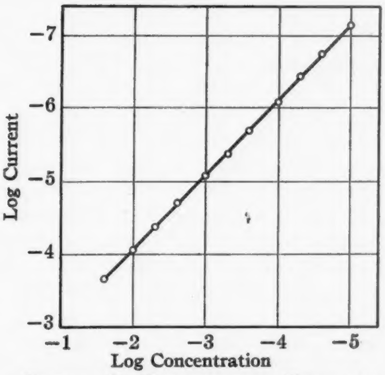

FIGURE 5.—RELATION OF DIFFUSION CURRENT TO THE CONCENTRATION OF CADMIUM IONS

Unknown concentrations can then be determined by comparison of the diffusion current with a graph similar to that in Figure 5 which has been obtained empirically with known solutions. However, such empirical graphs become useless when the capillary breaks, and a new calibration curve must be prepared for each capillary. The Ilkovič relationship, which will be discussed next, gives a means for correlating results obtained with different capillaries.

$I_d = Km^{2/3}t^{1/6}$. To test this important relation it is essential to have a dropping mercury electrode which will perform satisfactorily over a wide range of pressures. The electrode employed here was made of Jena capillary tubing, 6 cm. long, with an internal diameter of 0.05 millimeters.

Experiment 7.—Electrolyze, open to the air, a solution of about 5×10^{-3} *M* cadmium sulfate in 0.1 *N* potassium chloride at a constant applied E.M.F. of 1.0 volt from the saturated calomel electrode. Vary the pressure of mercury on the electrode capillary from 25 to 65 cms. in intervals of 5 cms. and observe the corresponding currents and drop-times. Also collect 10 drops of mercury in each case in a small glass cup beneath the solution. After washing with water and drying between filter papers, weigh the mercury on an ordinary student balance.

Table 1 gives the observed data in the first four columns. Note that the diffusion current, I_d, increases and that the drop-time, *t*, decreases with an increase in pressure, *P*, while the weight of each individual drop, *W*, is independent of the pressure. This means that at constant voltage a change in pressure will alter only the rate of dropping, not the size of the individual mercury drops. As will be seen, the latter is a function of surface tension and capillary characteristics. From Columns 3 and 4, we can calculate the quantity of mercury, *m*, which flows through the capillary per second. This quantity is directly proportional to the pressure, *P*, but is independent of the applied E.M.F. We then calculate $m^{2/3}t^{1/6}$ (Column 6). These values are in a constant ratio to I_d as shown in Column 7 and prove the correctness of this part of the Ilkovič equation.

TABLE 1

P	I_d	t	W	m	$m^{2/3}t^{1/6}$	$\frac{I_d}{m^{2/3} \cdot t^{1/6}}$	$P/m = \kappa$	tP	$\frac{I_d}{P^{1/2}}$
cm.	×1.24 micro-amp.	sec./drop	mg./drop	mg./sec.	mg.$^{2/3}$/sec.$^{1/6}$				
25	25.1	8.32	7.36	0.885	1.313	19.07	28.25	208	5.02
30	27.3	6.75	7.19	1.065	1.436	19.01	28.17	203	4.97
35	29.8	5.80	7.20	1.242	1.550	19.22	28.17	203	5.03
40	31.7	5.00	7.20	1.440	1.670	18.98	27.78	200	5.01
45	33.3	4.49	7.22	1.608	1.775	18.78	27.99	202	4.96
50	35.1	4.00	7.23	1.806	1.872	18.73	27.68	200	4.96
55	36.4	3.65	7.22	1.976	1.960	18.57	27.83	201	4.90
60	38.0	3.35	7.19	2.144	2.032	18.72	27.95	201	4.90
65	39.0	3.03	7.08	2.337	2.120	18.39	27.84	197	4.83
	Average		7.21			18.83	27.96	202	4.95

The Capillary Constant. On the basis of this relationship, Kolthoff and Lingane[7] proposed that every worker in the field of polarography include data for *m*, *t*, and the product $m^{2/3}t^{1/6}$ in his report. This suggestion has not been followed very widely because of the labor involved in determining *m* under each new experimental condition. It can be shown that each dropping mercury electrode can be characterized by a "capillary constant" which, when determined once under the simplest conditions can be used for all subsequent calculations concerning that particular capillary.

As is well known, Poiseuille has derived the equation governing the flow of liquids through capillary tubes:

$$\eta = \frac{\pi P r^4 t}{8Vl} \tag{8}$$

in which *V* denotes the volume of liquid of viscosity η, flowing through a capillary tube of length *l* and radius *r*, in the time *t*, and under the pressure *P*. Instead of volume *V*, we can substitute *W/d* where *W* is the weight of the liquid and *d* its density, thus:

$$W = \frac{\pi\, dr^4}{8\,\eta l} \cdot tP \tag{9}$$

For the case of the dropping mercury electrode, we may consider *W* as the weight of a single drop of mercury and *t* as the time necessary for the formation of this drop. *W/t* is then equal to *m*, the quantity of mercury flowing through the capillary per second, or

$$m = \frac{\pi\, dr^4}{8\,\eta l} \cdot P \tag{10}$$

which may be rewritten

$$P/m = \kappa \tag{11}$$

In other words, the ratio of pressure to the quantity of mercury flowing through the capillary per second is a constant characterizing the capillary used for the dropping mercury electrode.

The practical advantage of this observation is that the capillary constant κ has to be determined only once. For this purpose, it is not necessary to collect mercury beneath some solution and subsequently wash and dry it for weighing; instead, the mercury may be collected while the electrode is dropping in air. With the capillary constant κ known, only measurements of pressure *P*, and drop-time *t*—which are indeed simple—are needed in the individual experiment for the complete characterization of the dropping electrode. This can be proved experimentally.

Referring again to Table 1 we see that κ (Column 8) is independent of pressure, as expected. Column 9 was inserted to demonstrate that the product *tP* equals $W\kappa$, as required by equation (9). If we substitute from equations (9) and (11) into the relationship

$$I_d/m^{2/3}\,t^{1/6} = K \tag{12}$$

then

$$I_d\,P^{1/6}\,\kappa^{2/3} \Big/ P^{2/3}/\kappa^{1/6}\;W^{1/6} = I_d\;\kappa^{1/2} \Big/ P^{1/2}\,W^{1/6} = K \tag{13}$$

Since κ and *W* are constants $I_d/P^{1/2}$ is also constant, as shown in Column 10.

The following experiment is designed to prove that κ is also independent of the electrode potential.

Experiment 8.—Electrolyze, open to air, 10 cc. of 0.1 *N* potassium chloride at zero, 0.5, 1.0, 1.5, and 2.0 volts and at pressures of 64 and 29 cms., using the same capillary as in Experiment 7. At each setting observe the drop-time, and weigh 10 drops of mercury, which have been collected in a glass cup beneath the solution, washed with water, and dried between filter papers.

The results are given in Table 2 and show a satisfac-

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[7] KOLTHOFF AND LINGANE, *Chem. Rev.*, **24**, 1 (1939)

tory constancy of κ. The average values obtained here and in Experiment 7 compare even better than expected, considering that P was measured only to the nearest cm. Table 2 also demonstrates that while the drop-time changes with the change in applied voltage, the weight of mercury flowing from the capillary per second is constant at a constant pressure. This variation in the drop-time with the change in applied voltage is due to the changing surface tension of the mercury which is maximal at about 0.6 volt. This change in surface tension has been measured in Experiment 3*b* for the range of 0.5–1.9 volts by observing the drop-time at intervals of 0.1 volt. Plotting these values as curve *d* of Figure 3, we obtain a typical electrocapillary curve identical in shape with Kučera's curves,[5] in which the drop weight is plotted against the potential. This again indicates that the flow of mercury per second must be independent of the applied voltage. Since the diffusion current is proportional to $t^{1/6}$ it will also decrease as the potential increases above 0.6 volt, although to a less degree than the drop-time. This interdependence is clearly shown in curve *b*, Figure 3, where the diffusion current obtained in the reduction of lead ions decreases as the applied voltage increases.

TABLE 2

Applied E.M.F.	*P = 29 cm.*				*P = 64 cm.*			
v.	*t*	*W*	*m*	$P/m = \kappa$	*t*	*W*	*m*	$P/m = \kappa$
0.0	6.60	6.80	1.030	28.1	3.00	6.82	2.273	28.1
0.5	7.30	7.45	1.020	28.4	3.25	7.50	2.305	27.8
1.0	6.75	6.95	1.029	28.2	3.00	6.91	2.306	27.7
1.5	5.30	5.51	1.038	27.9	2.40	5.57	2.319	27.6
2.0	3.40	3.67	1.078	26.9	1.60	3.70	2.306	27.7
	Average			27.9				27.8

The next experiment serves to demonstrate the constancy of κ when the electrode drops in different media.

Experiment 9.—Using the same capillary as in Experiment 7, measure the drop-time and determine the drop weight at a pressure of 45 cms. while the electrode is (*a*) in air, (*b*) in distilled water, (*c*) in 0.1 *N* potassium chloride, and (*d*) in a buffer solution of 0.1 *M* ammonium chloride and 0.1 *M* ammonium hydroxide. No voltage is applied in this experiment.

The results are shown in Table 3. Note that the drop-time varies almost tenfold between air and potassium chloride while the drop-time in water differs little from that in potassium chloride. A more marked illustration of this point may be had if a drawn-out capillary of very narrow bore is used with a high pressure of mercury. The results shown in Table 4 were obtained using a capillary with an internal diameter of 0.015 millimeters at a pressure of 82 cms. Here the drop-time in air is thirty times as long as in potassium chloride, while a fivefold difference is observed between the drop-time in water and potassium chloride. Still m and hence κ are constant in this capillary at constant pressure.

TABLE 3

		Pressure 45 cm.		
Medium	*t*	*W*	*m*	$P/m = \kappa$
Air	37.0	59.7	1.611	27.9
Water	4.10	7.15	1.608	27.9
0.1 *N* KCl	4.45	6.65	1.621	27.7
Buffer soln.	3.92	6.31	1.600	28.1
		Average		27.9

TABLE 4

		Pressure 82 cm.		
Medium	*t*	*W*	*m*	$P/m = \kappa$
Air	127.0	56.2	0.442	185
Water	20.6	9.18	0.445	184
0.1 *N* KCl	4.25	1.87	0.439	187
Buffer soln.	6.4	2.83	0.442	185
		Average		185

Effect of Temperature. One factor which has been tacitly assumed as constant throughout this discussion is temperature. Although very little work has been done on this point its importance cannot be overlooked. This is illustrated by the following experiment.

Experiment 10.—Electrolyze, air-free, 10 cc. of 2.5×10^{-3} *M* cadmium sulfate in 0.1 *N* potassium chloride solution at a constant voltage of 1.0 volt. A layer of mercury serves as anode. Place the electrolysis vessel in a water bath cooled by ice. Observe the temperature and the corresponding current, and vary the temperature in convenient steps by the addition of warm water. Stir the solution in the electrolysis vessel by bubbling nitrogen through it.

The results obtained are plotted in Figure 6 and show a temperature coefficient of about 1.5 per cent at room temperature. From this it becomes evident that if the temperature is not controlled better than 1°C., errors due to temperature will amount to ±2 per cent. Most of this effect is due to the change in the diffusion coefficient of the reducible substance with change in temperature, but part of it is caused by the altered flow of mercury through the capillary due to the change in the viscosity of mercury with change in temperature.

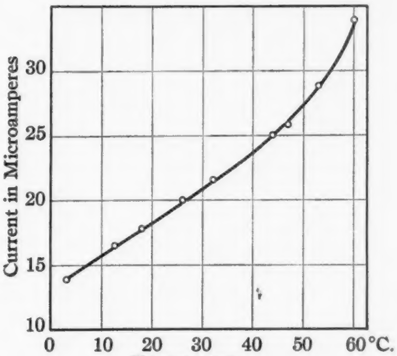

FIGURE 6.—EFFECT OF TEMPERATURE ON THE DIFFUSION CURRENT OF CADMIUM IONS

More Effective Organic Laboratory Instruction[1]

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Manhattan College, New York City

THE greatest shortcoming of the time-honored method of conducting the elementary organic laboratory has probably been its lack of student appeal rather than any inherent inadequacy in the material offered. This is quite apparent in a group where most of the students are fulfilling a prerequisite rather than building a chemical education. But whatever the group composition, the laboratory is a more effective companion to the lectures it augments whenever it is more inviting to the average student. Once his favorable attention can be gained, his interest and confidence follow. From this springs a desire to participate, and finally the development of an ability to examine, correlate, and think in terms of the facts and principles of the subject as it is progressively unfolded to him. A prime requisite for this philosophy of presenting elementary organic chemistry is an appropriate laboratory program.

The present laboratory program at Manhattan College recognizes two important factors in its attempt to produce a more effective and attractive course for a group in which chemistry majors are in the minority. A certain number of varied preparations have a real value which should not be sacrificed. And secondly, a semester devoted solely to a highly organized (although abridged) scheme of analysis might easily defeat its purpose in becoming as much of a routine cookbook process as the series of preparations and tests it replaces.

A four-year period of trial and improvement has evolved a system which includes eight to nine preparations each semester, accompanied by a total of fifteen assigned analytical unknowns during the year. Initial laboratory periods are devoted to explanations and experiments to acquaint the beginner with distillation, recrystallization, and the like. A micro boiling-point method is introduced by an exercise in which this constant must be reported for two unknown samples. There follow three to four preparations, after which the first analytical sample is given. For the remainder of the year these are passed out intermittently or concurrently with the assigned preparations, about two-thirds of them being distributed during the second semester. The first two unknowns are intentionally very simple, permitting the student to develop a method of attack, the habit of critically consulting and thinking in terms of the text material already covered, and an appreciation of the need to observe carefully the physical and chemical properties of all compounds encountered. They are chosen from some reactant or product of a previous preparation, or a solvent in common use—selected to permit an easy choice and preparation of an appropriate derivative. The rather prompt success of these initial investigations thus leaves the student confident rather than overawed in the face of more samples to come.

The succeeding samples are more challenging, but ever within the classes of compounds already studied in class. One sample is always a carbohydrate, and five or six are aromatic compounds. Ultimately each student analyzes thirteen to fifteen types of compounds. No individual compound need be used more than five times during the year in a group of forty students. The unknown sample weighs about three grams.

When the first unknown is distributed a class explanation of procedure is given. It is pointed out that the primary purpose of the series of identifications to follow is to intensify the classroom lectures and so to learn organic chemistry, rather than to develop analysts in an elementary course. Questions and consultations with the instructor and even with fellow students are encouraged. While the teacher may refuse to answer a specific question which constitutes a part of the solution, he can still use the individual contacts offered for much good instruction. On such occasions he is also able, by discreet questions and suggestions of his own, to prevent the student analyst from wasting too much time with blind leads into which his inexperience may carry him. At all times, however, the ultimate decision on tests, derivatives, and reported conclusions rests solely with the student.

A bound booklet developed for the purpose is presented with the first unknown. It outlines a general procedure consisting of fusion with sodium, the determination of the melting or boiling point, the acidity, density, solubility, etc. Reference to Kamm's solubility chart[2] as an aid in judging the type of compound is suggested. Methods of preparing derivatives for a large number of acids, alcohols, and for certain phenolic, carbonyl, and amino compounds are given, accompanied by melting-point lists of the solid derivatives so produced. New analytical contributions providing additional sources of derivatives, new tests, or interesting and instructive reaction technics are periodically added in outline form, or briefly noted by exact citations. The booklet concludes with a composite list of approximately five hundred compounds which comprise the system. Beyond arranging these compounds in the order of their increasing melting or boiling points as may be the case, all classification has been carefully avoided.

About two hundred of the substances entered are

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[1] Presented before the Division of Chemical Education at the ninety-eighth meeting A. C. S., Boston, Massachusetts, September, 14, 1939.

[2] KAMM, "Qualitative organic analysis," 2nd ed., John Wiley and Sons, Inc., New York City, 1932.

currently used. These are representative compounds for which exact or analogous directions needed for preparing derivatives can be found in any standard elementary manual, so that the student is seldom forced to seek further, although this is permitted. Upon this nucleus the composite list has been built by padding with carefully selected additions so that five to twenty compounds of various types appear within five degrees above or below any sample issued. The following excerpt from the list as now constituted, with some of the entries suitable for use in this elementary scheme capitalized, serves to illustrate the padding effect:

m. p.	*b. p.*	
150		*o*-bromobenzoic acid
	151	bromoform
153		cinnamanilide
	153	cumene
	154	pinene
154		thiocarbanilide
	154	ANISOLE
	155	cyclohexanone
	155–6	BROMOBENZENE
156		benzenesulfonamide
	157	*n*-HEXYL BROMIDE
158		*m*-chlorobenzoic acid
	158	*n*-propylbenzene
159	76 (subl.)	SALICYLIC ACID
−34	159	*o*-CHLOROTOLUENE
	160	cyclohexanol
	161	furfural
7.5	162	*p*-CHLOROTOLUENE
−48	162	*m*-chlorotoluene
	163.5	*n*-BUTYRIC ACID

Specific instructions for a complete and satisfactory report are included in the booklet. Equations are required for all reactions performed. Evidence must be cited to eliminate all listed compounds within the ten-degree range mentioned above. A student receiving a liquid boiling at 157° just before the end of the first semester, upon referring to his text would discover the identity of cumene, pinene, anisole, and furfural, along with realizing that neither these nor bromobenzene, *n*-propylbenzene, nor the chlorotoluenes were possibilities since they were types of compounds yet to be encountered in class. That the compound was a liquid, containing a halogen atom, insoluble in and heavier than water, would then indicate that a derivative for *n*-hexyl bromide was in order. The same situation in the second semester would demand consideration of many more of the possibilities just mentioned with special attention to distinguish between *n*-hexyl bromide, bromobenzene, and the chlorotoluenes. The student is free to use or reject any general or specific test in an analysis, but must give reasons for so doing. The accumulated evidence is then summarized, pointing to the analyst's conclusion and the choice of derivative indicated.

The completed report must be accompanied by a purified suitable derivative, the amount of which is immaterial. Reports which are otherwise correct but unaccompanied by a derivative, for whatever reason, receive somewhat more than a minimum passing grade but no new sample is issued. The total number of analyses submitted since their introduction now exceeds 2000. Of this number, 41 per cent have received a perfect grade, and another 23 per cent have received grade deductions only because the derivatives were impure or missing. In all, 64 per cent of all samples have been correctly identified, the corresponding values from year to year ranging between 60 and 70 per cent.

Most students need only the text and laboratory manual to complete their series of analyses. Since a wide acquaintance with other texts, manuals, and journals is in itself desirable, however, this lack of any need for them is never emphasized. Several popular laboratory manuals, along with copies of a few books on qualitative organic analysis, and many standard texts of organic chemistry are kept available for ready reference. Regular use of standard analytical texts is not desirable, however, as it tends to defeat the purpose of the system in supplying tests and suggesting derivatives without any need for thought about these matters on the part of the student. Without them, he is normally forced to discover and decide upon tests and derivatives to be expected on the basis of the chemistry of the type of compound under consideration, as learned through lecture and the text. Following these choices he normally turns to the laboratory manual for guidance in performing the reactions indicated.

This new method has produced economies in equipment and chemicals, the development of a precise and neat laboratory technic, and a respect for clean apparatus so often missing in the organic laboratory. The student is enabled to test and to prepare derivatives from every important type of compound studied in the classroom, under circumstances wherein he participates with an interest not attainable in any other way. And he does this in about one-half of the time which would be required for the same experience on the discarded preparation-and-observation basis.

But more important are many other desirable features which seem inherent to this particular modification for utilizing organic qualitative analysis. To enumerate:

1. The continuing series of selected samples keeps the student in close contact with current and past classroom work, enabling him to use his acquired knowledge on problems within his attained organic stature.
2. The preparations selected can be spaced so as to be most advantageously related to the lectures.
3. Laboratory work is highly individual, necessitating personal attention and observation, and eliminating copying. Consulting is common, but can be only of mutual advantage to those concerned.
4. There is a minimum chance for the analytical process to degenerate to a thoughtless cookbook routine.
5. The scheme is adaptable to any thorough laboratory manual, with text.
6. Frequent contacts for instruction under the best possible conditions for effectiveness are provoked.

7. By substituting extra unknowns for occasional preparations which have come to grief after many hours spent on them, the student may recoup his grade, learning even more chemistry than by repeating the preparation, yet losing but little time through his misfortune.
8. The idea has proven student appeal. Having put forth an earnest effort to use such organic chemistry as he knows, the analyst is anxious for a decision on his report, to uncover his errors, and to seek an explanation for any hazy or controversial feature. More excellent instructional contacts under receptive conditions.
9. And lastly, the complete program meets the recommendations of the A. C. S. accrediting committee[3] for the inclusion of an adequate treatment of qualitative analysis in the elementary organic laboratory.

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[3] *Ind. Eng. Chem., News Ed.*, **17**, 271 (1939).

A Space Model of the Carnot Cycle

E. W. KANNING and R. J. HARTMAN *Indiana University, Bloomington, Indiana*

NICOLAS Leonard Sadi Carnot published in his memoirs[1] in 1824 the conclusions which verified the fundamental concepts of the First and Second Laws of Thermodynamics. He considered the ideal cyclic process involving the reversible conversion of heat into work, which now bears his name and which constitutes a portion of the section on thermodynamics in any physical chemistry textbook.

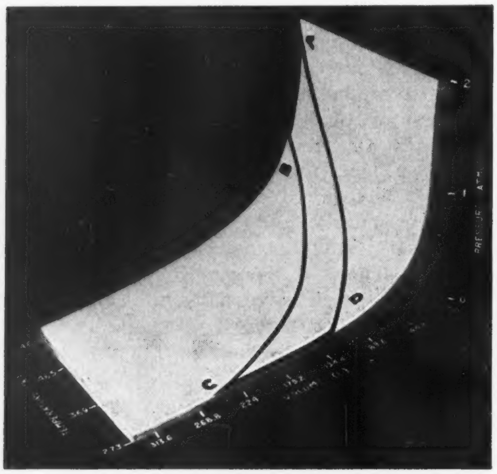

FIGURE 1.—CARNOT CYCLE

It is the purpose of this article to present a model of a typical Carnot cycle in order to show more clearly the four steps of this process. The cycle involves changes of pressure, volume, and temperature, and therefore a two-dimensional drawing is not wholly adequate. The model, shown in the photograph (Figure 1), is made of plaster of Paris set on a wooden base. The cycle, *ABCD*, is clearly shown on the face of the model. Figures 2, 3, 4, 5, and 6 are labeled to correspond to those faces as shown in Figure 1; the dimensions given in centimeters are those of the model from which the photograph was taken.

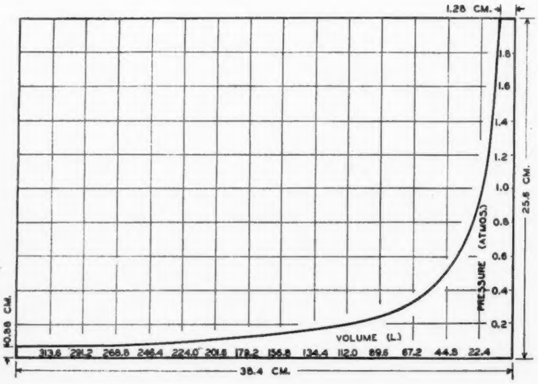

FIGURE 2.—FRONT SIDE

According to this model, the cycle begins at point *A* at which there is one mol of a perfect gas (hydrogen) at 546°K. and two atmospheres pressure. As the gas is allowed to expand isothermally and reversibly at this temperature, the volume and pressure change along the line *AB* until the point *B* is reached where the pressure is one atmosphere and the volume is 44.8 liters.

The second step of the cycle begins at point *B* where an adiabatic expansion takes place while the temperature is lowered from 546°K. to 273°K. For this adiabatic expansion of a perfect gas the equation

$$PV^{\gamma} = 2.639$$

where

$$\gamma = C_P/C_V = 1.4$$

is true and thus the curve *BC* is outlined on the face of the model.

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[1] CARNOT, "Réflexions sur la puissance motrice de deu et sur les machines propres à développer cette puissance," Paris, **1824**.

The third step is an isothermal reversible compression of the gas as shown along the line *CD*; since the temperature remains constant (273°K.), the pressure must increase as the volume decreases.

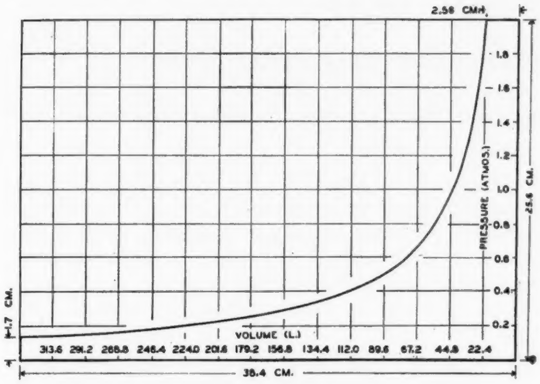

Figure 3.—Back Side

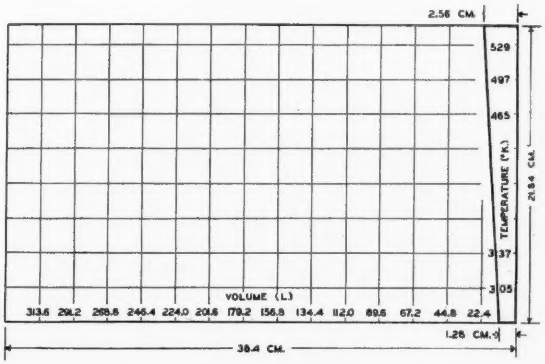

Figure 4.—Top

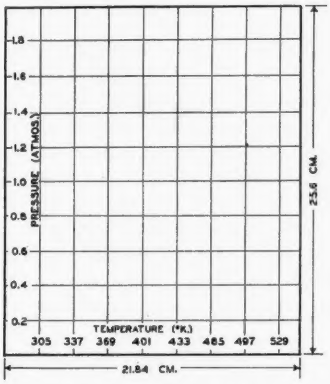

Figure 5.—Right End

The fourth step of the cycle is an adiabatic compression such that the final volume is equal to the original volume. For this adiabatic compression the equation

$$PV^\gamma = 2.000$$

is true and is shown as the curve *DA* on the model.

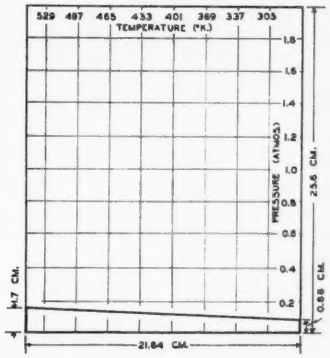

Figure 6.—Left End

When the cycle *ABCD* is projected on the pressure-volume plane, it appears as shown in Figure 7. The shape of this diagram results from the actual changes in pressure and volume through which the perfect monatomic gas passes.

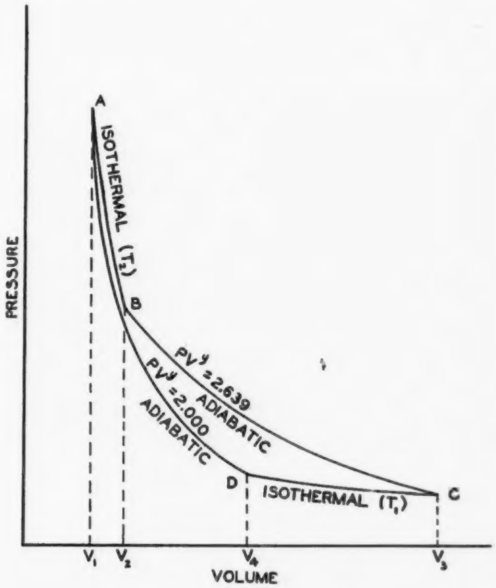

Figure 7.—The Carnot Cycle in the Pressure–Volume Plane

Since the mathematical development and use of the Carnot cycle in thermodynamics is adequately described in the better texts on physical chemistry and thermodynamics, this treatment is omitted.

The Atomic Arrangement in the Sulfur Unit Cell

A Description of an Illustrative Model

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THE model described in this article attracted considerable attention at the New York World's Fair, where it was on display at the exhibit of the Texas Gulf Sulphur Company in the Industrial Building. The problem in design was to show the arrangement of the atoms in the sulfur unit cell in a convincing manner, and, at the same time, to prepare as novel and modern a representation as possible in order to keep in harmony with the underlying theme of the fair. A considerable measure of success in this aim was finally attained, without too much cost, by the use of the plastic, methyl methacrylate.

The axes of the unit cell of rhombic sulfur have been determined by Warren (*5*) as follows: a = 10.48A., b = 12.92A., c = 24.55A. Other observers are apparently in good agreement on these values (*4*) (*2*). Warren has concluded that the unit cell is made up of sixteen puckered rings, containing eight atoms each. The bond angle between adjacent atoms in the molecule is 105°; the distance of closest approach is about 2.1A., which is just twice the covalent atomic radius given by Pauling (*3*), so that apparently adjacent atoms touch each other within the molecule. From these data one is able to calculate the dimensions of the molecule, which may be considered as consisting of two squares, one turned 45° with respect to the other, whose planes are separated by 1.15A. and whose sides are 3.38A. From rotation and oscillation photographs, Warren has calculated the atomic coördinates and worked out the positions of the rings in the unit cell. The molecules lie in four layers perpendicular to the c axis. The planes of the rings in any one layer are approximately parallel to one of the diagonals of the c face, while in the next layer the planes are all parallel to the other c face diagonal. It is this representation of the structure that the model portrays, as shown in Figure 1, a closeup view.

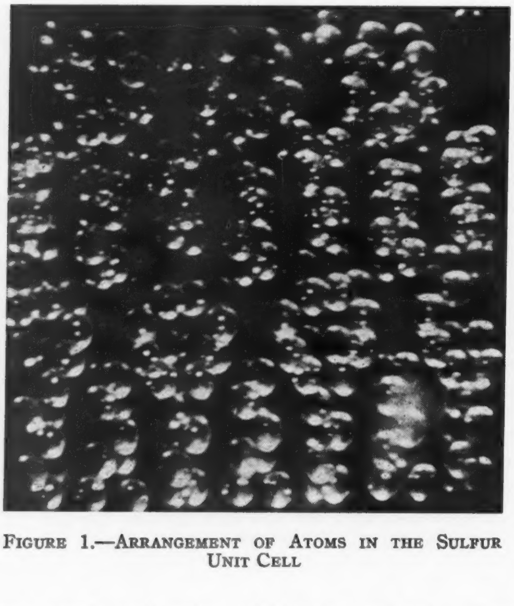

FIGURE 1.—ARRANGEMENT OF ATOMS IN THE SULFUR UNIT CELL

Each atom is represented by drilling part way into the back side of a "Plexiglass" plate, using a $^5/_8$-inch bit. Viewed from the front and with the aid of suitable illumination, the holes give the illusion of spheres suspended in space without any visible means of support. The entire model is composed of twelve such plates, each of proper thickness and containing holes representing atoms lying in the same plane. Thus the effect of depth is obtained by superimposing the plates one behind the other, in the order indicated in Figure 2. A point of view has been chosen by which some of the puckered rings appear almost as an end view; the others are seen in a side view. This arrangement means that the plate length corresponds to the c axis and the plate width to the diagonal of the c face.

The templet for drilling each plate is shown in Figure 2. The distance from center line to center of hole is 0.46 cm. unless otherwise indicated. Other constant dimensions are shown only on Plate 1. All dimensions are in centimeters. Each hole should be drilled until the maximum diameter is attained even though in some cases it means drilling through the plate and into the previous one. The design illustrated comprises one unit cell only, although the model can be extended to include as many atoms as desired by simply repeating the basic pattern. The finished product on display at the New York World's Fair represented more than the one basic unit cell. With the aid of proper edge lighting, the holes were made to appear as strongly illuminated spheres, owing to the diffusion of light from the drilled surfaces. The effect is best brought out by using a flush mounting on a panel board, preferably black.

Both Warren (*5*) and Bragg (*1*) have demonstrated the structure believed to exist in the sulfur unit cell, in so far as it is possible to do so in a two-dimensional drawing. The model described in the foregoing paragraphs has been built up from the latest atomic data

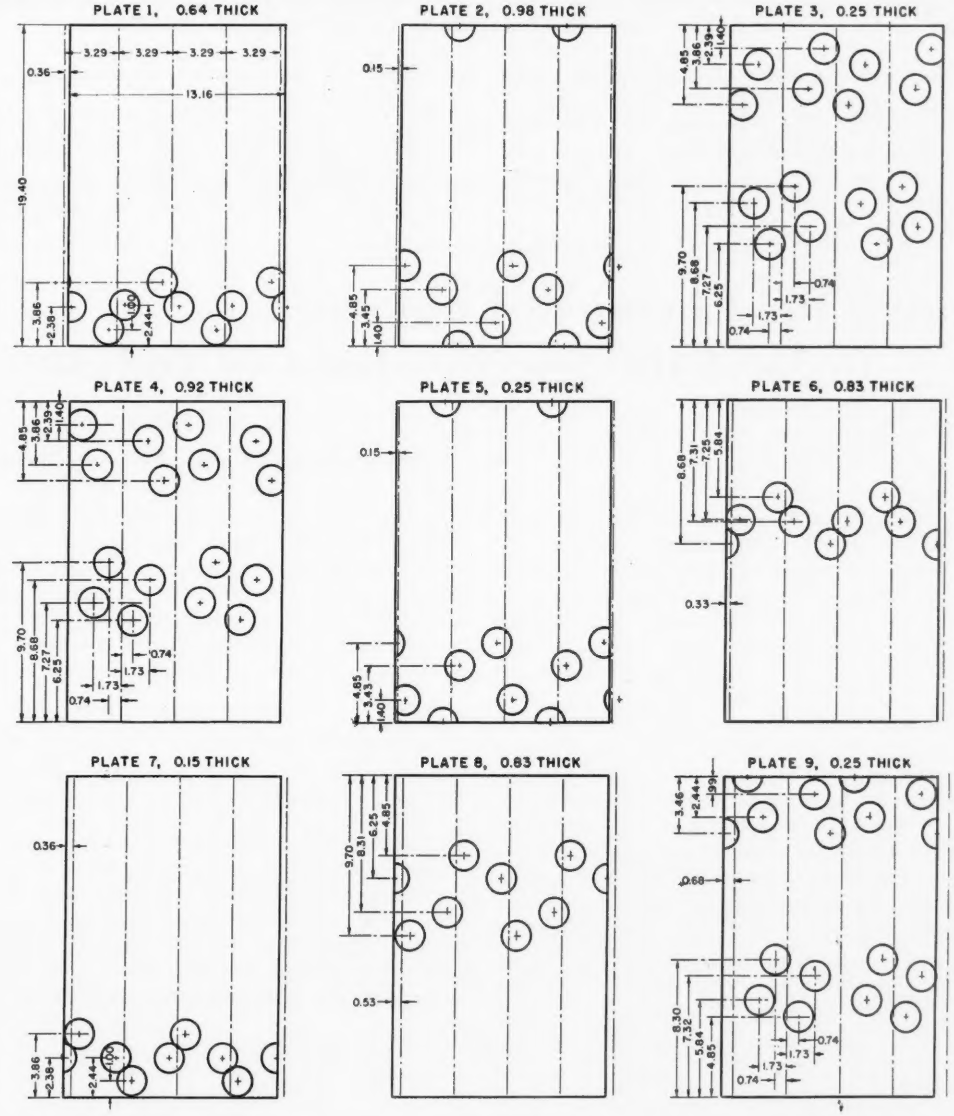

FIGURE 2 (PLATES 1–12).—DESIGN OF PLATES FOR CONSTRUCTING A MODEL OF THE SULFUR UNIT CELL

on sulfur and may possibly afford a somewhat easier visualization of the entire unit cell. The method of design used here may, of course, also be extended to other crystals whose structure is known, but whose picturization is made difficult by the structural complexities involved. Credit is due Mr. R. P. Murray, formerly with Jenter Displays Company, but now with The Displayers of New York City, who originally conceived this method of showing the structure of the sulfur unit cell and who supervised the construction of the model illustrated.

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(4) TRILLAT AND OKETANI, *Z. Kryst.*, **98**, 334–43 (1937).
(5) WARREN AND BURWELL, *J. Chem. Phys.*, **3**, 6–8 (1935).

Training the Chemical Engineer to Meet the Specifications of Industry[1]

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EVERY industry wants young men who eventually will be able to help that industry develop by producing better products and better processes. It makes no difference what the industry is; the type of men required and their fundamental training will be for all practical purposes the same. This does not mean that their activities in the industry will be confined to the research department, for it is quite possible for members of the sales department, for example, to aid materially in the development of new products and new processes.

The graduate in chemical engineering who eventually will be successful in industry will have the same viewpoint as the industrial leaders and have an ardent desire, even as a student, to fit himself for this type of work. He will enjoy doing original technical work which results in the acquisition of scientific or engineering facts that may be put to some useful purpose. This attitude of mind is quite common among our better students of chemical engineering, and many young men are drawn into the chemical engineering curriculum because it offers a broad training in fundamental science, coupled with an understanding of how these scientific facts can be applied to industry.

RESEARCH AND DEVELOPMENT

Any research work that the young chemical engineer may do, once he has obtained a position in industry, is susceptible to fairly accurate analysis in order to determine the common method of attack on a specific problem. Such an outline is given in Table 1. It is essential that this general method of attack should be studied first in order to determine what it is that causes one man to be successful while another, with seemingly equal ability, fails to solve the problem.

It will be noticed that for a new process, product, or equipment the general scheme used by most of our

TABLE 1

RESEARCH AND DEVELOPMENT

Process or Operation (For both manufacturing and analytical purposes)	*Product*	*Equipment*	*Formula or Equation*
1. Literature search and conferences 2. Selection of the process or operation with best possibilities for development 3. Factors involved *Examples:* Temperature Pressure Concentration Physical and chemical properties of each and every constituent 4. Means of varying each factor 5. Selection of the particular factor and particular means of varying it to be the object of the experiment	1. List faults and virtues of old product 2. List other similar products never before used for the particular purpose. (Literature search and conferences) (*Note:* This list often includes products not in existence at the moment, but products believed to have very desirable properties, due to theoretical considerations.) 3. Selection from this list the one that seems to offer the best opportunity for development 4. Then follow items 3, 4, and 5 under "Process Method"	Adapt "Product Method"	1. Run operation under all probable conditions taking all pertinent data, keeping all variables constant except one during a single run 2. Determine capacities, efficiencies, rates, etc. 3. Express capacity, etc., in terms of the important variables by the use of the common type of formula *Example:* $x = K\frac{A^m \cdot B^n \cdot C^o}{D^p \cdot E^q \cdot F^r} + K'$ Where K, K', m, n, o, p, q, and r are constants and the remainder are variables. The position of the variables, whether in the numerator or denominator, is determined by whether or not x (capacity, etc.) increases or decreases with an increase of the particular variable. 4. The arithmetical values of the exponents and constants are determined by mathematical cut-and-try methods. The equation is correct if calculated values of x agree with those determined by experiment

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[1] Presented before the forty-eighth annual meeting of the Society for the Promotion of Engineering Education in Berkeley, California, June 24, 1940.

TABLE 2

Appraisals

Capital Cost, Probable Profit, and Length of Life

Patents

1. Extent of coverage of the claims
2. Exactness and completeness of specifications
3. Range of variables
4. Underlying patents owned by outsiders
    (*a*) Raw material
    (*b*) Process
    (*c*) Equipment
    (*d*) Product and by-products
5. Validation in a court

Raw Material

1. Present and future cost
2. Extent and adequacy of present and future source
    (*a*) Number of producers
    (*b*) Location
    (*c*) Collection and transportation
    (*d*) Seasonal production
    (*e*) Waste material
3. Storage
4. Legal requirements
5. Tax, tariff, etc.

Processes, Operations, and Equipment

↓

Economic Balance

↓

Product and By-products

1. Factors involving both old and new products
    (*a*) Number of customers and extent of sales field in comparison to possible production
    (*b*) Familiarity with technical uses
    (*c*) Specifications and purity required
    (*d*) Distribution problems
        (1) Location of consumer
        (2) Package or container
        (3) Safety factors
        (4) Seasonal sales
        (5) Legal requirements
        (6) Storage
        (7) Trademarks and product patent
    (*e*) Possible future developments
2. Factors involving old product, future price range, and effect of increased production
    (*a*) Character of competition
        (1) Number and character of producers
        (2) Trade agreements
    (*b*) New uses
    (*c*) Taxes, tariff, etc.
3. Factors involving new product; extent of sales promotion
    (*a*) Technical sales service
    (*b*) Advertising
    (*c*) Time required
    (*d*) Possibility of a product patent
4. By-products (gases, liquids, and solids)
    (*a*) Disposal factors
        (1) Corrosion
        (2) Toxicity
        (3) Explosive characteristics
        (4) Legal requirements
    (*b*) Transformation to a salable product (a separate appraisal)
        (1) Production balance
        (2) Storage

Economic Balance

Physical and Chemical Properties

1. Contributing subjects
    (*a*) Inorganic chemistry
    (*b*) Organic chemistry
    (*c*) Physical chemistry (quantitative principles of chemistry)
    (*d*) Physics and mechanics
    (*e*) Thermodynamics
    (*f*) Quantitative analysis
2. Approximation methods

Material and Energy Balances

1. Contributing subjects; largely chemistry, physics, thermodynamics, and industrial stoichiometry

Rate Studies

Chemical Kinetics

Chemical Engineering
(fluid flow, heat transmission and diffusion)
1. Unit operations
    Examples:
    Evaporation
    Drying
    Distillation
    Gas Absorption
    Extraction
    Crystallization
    Mixing
    Filtration
2. Unit processes
    Examples:
    Pyrolysis
    Oxidations
    Reductions
    Hydrations and Dehydrations
    Hydrolysis
    Esterification
    Polymerization
    Halogenation
    Nitration
    Sulfonation

Possible Future Development

research and development workers is very similar and can be briefly stated by saying that a list of factors and means for changing these factors are determined in advance of the experimental work. The proper selection of the factor and method of change is quite evidently of extreme importance. Time will not permit, even in the simplest problems, experimental work involving all factors and all methods of changing these factors. Some research problems would take easily a lifetime if this scheme of research were carried out. The successful worker is the man who is able, due to his knowledge and foresight, to select the critical factor and the method of changing the same. This selection is based on an accurate appraisal of several possibilities, and this appraisal in turn depends on a great many different subjects which the worker must know or a knowledge of which he must acquire in a relatively short period of time.

If the assumption is correct that our young chemical engineers will be successful in industry largely because of their research ability, then it is evident that this ability will depend largely on their capacity to make accurate industrial appraisals. In fact, this statement can be made even broader by saying that industry itself grows and prospers largely because of the ability of its leaders to make accurate appraisals that hold good, not only for today, but also for the future.

ECONOMIC INDUSTRIAL APPRAISALS

The chief executive of an industrial concern, who is asked to pass upon a new development, wants to know three things: the capital cost, the probable profit, and the length of time that the venture will pay adequate dividends. The answer constitutes an accurate economic appraisal. If the estimate is accurate, a decision can be reached without any real expenditure of energy and time. On the other hand, such an ideal appraisal is rare because, as shown in Table 2, there are so many questions involved to which no definite answer can be given.

The main sub-headings in Table 2 are: Patents, Raw Materials, Processes, etc., and Products. Patents have been made a main sub-heading because this subject is involved in the remaining three and because of its commercial importance. The purchasing department is deeply interested in the raw material, while the sales department confines its attention largely to the product and the by-product. The engineer, however, is largely interested in the heading which comprises processes, operations, or equipment, because it is here that his technical training will be of most value. Even the young engineer, however, should be familiar with the other more or less non-technical subjects, because in order to make an accurate appraisal these matters must be considered. Such matters as distribution of a product are of vital importance to the successful development of even a small plant. The source of the raw material often determines the selection of a particular process to be used in the plant. Patents frequently are the cause of the commercial success or failure of any particular process or operation. It is, therefore, evident that our chemical engineering student should have at least a casual acquaintance with these subjects before he starts work in industry.

ECONOMIC BALANCE

The engineer and applied scientist is always faced with the problem of producing a new process, operation, or piece of equipment which will give the greatest return over a period of time on the capital invested. This problem of selection can often be reduced to mathematics by which an economic balance is made in order to show what design or what means of operation or what process should be utilized to obtain the best financial result. It is this appraisal, or the creation of an economic balance, which is vitally necessary in all industrial research and development work. It is quite evident that the student in chemical engineering must have the technical background necessary to solve the problem. While he is a young man, the problems presented to him of this nature will be comparatively simple, and it will be left to others to make the more complicated and more inclusive appraisals. However, it is often essential for the young man to know something about the overall appraisal in order that he may be able to adjust his own work so that the final result will be of benefit to the industry. As time goes on, if he is successful with the smaller problem, he will be permitted to report on the larger problem until eventually, because of his reputation of making accurate estimates, he will become a very influential figure in the industry.

The acquiring of the necessary data to make an accurate economic balance for a process or operation depends on the worker's ability to determine definitely certain physical and chemical facts. These data may be divided into two main groups. One involves equilibrium conditions, and the other rate studies.

Conditions such as temperature, pressure, concentrations, etc., can sometimes be determined at a critical point in the operation by direct means. These may even be evaluated by statements made in the literature. Often only approximations can be made, and it is common practice to use for engineering purposes any means the designer has to obtain a value of apparently reasonable accuracy. Frequently calculations can be made and the data determined by setting up a material or energy balance. Such calculations and collection of data have to do with equilibrium conditions.

It is also very important to be able to determine rates of chemical reactions, physical transformations, or a combination of both. It is here that we have the basis of chemical engineering. It is obvious, however, that in a study of rates of reactions or physical transformations it is essential to know conditions that exist during dynamic equilibrium.

COURSE OF STUDY FOR THE CHEMICAL ENGINEERING STUDENT

If the assumption is correct that our chemical engineering graduate will be asked to do research and development work, and his ability to do this depends on the accuracy of his appraisals, and if our outline covering an economic industrial appraisal includes all of the common and important factors necessary, then it is obvious that they should constitute the major subjects of study for the student.

Chemistry, physics, mechanics, thermodynamics, and chemical engineering are evidently the five major technical subjects. It is obvious, also, that the quantitative principles of chemistry as taught in physical chemistry are of extreme importance. A broad chemical and engineering thermodynamics that will be of use to the chemical engineer rather than the thermodynamics usually taught to mechanical engineers or to chemists is what is needed. The application of both physical chemistry and thermodynamics to the industrial problems which the young man will meet after he is graduated is a matter that should be given much more attention. In fact, it might be possible to eliminate from the present curriculum much of the steam engineering, mechanical engineering, and electrical engineering that now serves very little useful purpose, providing that important and essential portions of these old courses were given in courses in physics, mechanics, and thermodynamics.

It is also obvious that after a perusal of the appraisal chart the subject chemical kinetics should be stressed. Along with heat transmission, fluid flow, and diffusion, it constitutes the foundation of the work on the design of chemical engineering equipment in which a chemical reaction takes place. Many schools in this country have been giving some instruction in this subject, known as unit processes, but owing to its complexity very little of this work has been allotted to the undergraduate curriculum. It is felt, as we acquire from industry more data and information concerning the design of such equipment, that unit processes will receive more attention in our schools.

It is also very apparent that the chemical engineering student should be given, early in his program, problems involving an economic balance and that he should be exposed to this type of problem from then on until he graduates. It is this practice which gives the graduate a glimpse of what he will meet when he enters industry, and smooths his way during the transition period. Problems of this type can be combined with laboratory and even research work. Considerable attention has been given to this subject in the last few years in the United States, and many different types of project courses have resulted.

It will be noted that the appraisal outlined does not require any particular specialized knowledge. This fact has been appreciated in recent years. Here in the United States there has been a distinct tendency to remove all specialized technical courses such as petroleum engineering, ceramic engineering, technical analysis courses, etc., from the curriculum. The list even includes industrial chemistry. Experience has shown again and again that the so-called industrial chemistry can be taught best by using industrial-chemical examples in more fundamental courses. On the other hand, there exists a class of specialized subjects which may or may not be necessary from the student's standpoint, depending on whether or not he intends to go into certain industries. Such elective subjects are for example: bacteriology, metallurgy, and applied electrochemistry.

It is recognized, of course, that there are several very important subjects of study that are not of a technical nature and, therefore, do not appear among the contributory subjects in the table.

Mathematics is one of these. The tendency today is to rely on the high school for teaching of elementary algebra and trigonometry. Analytical geometry is disappearing from the college curriculum, and calculus is appearing in the first year of study. Differential equations and higher mathematics, as used by the engineer, are coming into the curriculum. The difficulty seems to be to find the teacher of mathematics who is interested in engineering.

The ability to use one's native language cannot be overstressed. In the United States the criticism of industrial men employing young chemical engineers has always been that these young men are unable to express themselves clearly and concisely, either orally or in the form of reports. This should be done in the secondary schools, but it is not. The teaching of English or rhetoric is accomplished in some of our universities by having the student write themes until two or three have proven satisfactory and then to require him to re-enter the course if he fails to write a satisfactory report in any other course at any time during the four-year period. This method has shown excellent results.

The study of scientific French and German for our chemical engineers has always received serious consideration. Recently, in certain schools, notably Purdue University, a course in chemical German has been organized after years of research, in which there is taught only the grammar and vocabulary necessary for an adequate understanding of chemical articles. The results indicate that this is a very satisfactory method.

Mechanical and free-hand drawing as a mode of expression is not, of course, overlooked.

Considerable discussion has taken place in recent years concerning the addition to the curriculum of a course in contemporary civilization. Columbia University has the outstanding example of a successful course in this subject. They employ approximately thirty instructors covering four main subjects: economics, philosophy, history, and political science. They coördinate the material in an attempt to show the engineering student how modern civilization came to be. They try to give him an understanding, not only of national questions, but also of international affairs. Furthermore, in the second year, they attempt to extrapolate the curve and give an indication of what may happen in the future. Experience has shown that this, even from a monetary standpoint, is perhaps the most valuable course ever given to an engineering student. It is hoped that in the future not only all of our chemical engineering curricula will embody such a course but also every college and university student will be at least exposed to this subject.

It always has been felt that our students are entitled to spend some time on the humanities. It should be possible to create, or at least to promote, a desire to know more about these subjects and thereby make life more pleasant. A course in the appreciation of literature, music, and art is distinctly worth while, providing instructors can be found who not only know the subject but have the ability to stimulate interest in others.

It should be noted that these non-technical courses added to the list of required technical subjects at the present time would necessitate more than a four-year program of study. The economics of the situation, which is usually the controlling factor in both course selection and length of program, demands that future curricula do not exceed four years, and means must be found to eliminate the less important subjects for more important ones.

A LABORATORY EXERCISE IN FREEZING POINT DEPRESSION WITH CAMPHOR AS THE SOLVENT

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LABORATORY manuals of general chemistry often include an exercise which applies the cryoscopic or freezing point depression principle in the determination of molecular weights. The procedure usually requires the use of special apparatus with expensive thermometers where such solvents as benzene, water, and so forth are used. For these and other reasons the disadvantages of the cryoscopic method often make its use as an experiment for the individual student almost prohibitive. The writer has attempted to devise an exercise which would circumvent many of these difficulties. In so doing, a degree of compromise in the accuracy of results had of necessity to be made. In the opinion of the writer the advantages gained in simplicity of technic and design justify the sacrifice in accuracy of results.

The cryoscopic constant for camphor is given by some handbooks to be 49.8.[1] Thus, a mol of solute dissolved in camphor will produce a depression of the freezing point which is around nine times as great as that produced by a mol of solute in benzene. This large constant, in effect, magnifies the freezing point depression for a solute in camphor to such an extent that an ordinary thermometer with a range of 200°C. can be used. The advantage of this has been recognized in the use of camphor as a solvent for micro molecular weight determinations.[2] However, as far as the writer knows, no experiment employing this method for the use of general chemistry students has been described. The following gives an exercise in which salicylic acid is the solute and camphor the solvent. The approximate molecular weight of the solute may be calculated from the data obtained.

The freezing point of the camphor used is determined. From one hundred to two hundred milligrams of salicylic acid are weighed into an ordinary five-inch test tube. The weight of the camphor used may conveniently be from twelve to fifteen times as great and should be weighed to the centigram. The camphor is easily handled when cut into small shavings. The tube is stoppered with cork, placed into a bath at a temperature of 160°–170°C., and the mixture melted rapidly in this temperature range. The bath used is a beaker containing 350–400 ml. of cottonseed oil. The tube and contents should be kept well submerged in the bath. The temperature of the bath is allowed to fall gradually, while the test tube is gently agitated in proximity to the bulb of the thermometer, until small white specks appear throughout the solution in the tube. The temperature is immediately read. The freezing point of the mixture may be rechecked and an average taken. Each student may make three or more determinations.

Experience with this procedure has shown that around fifty per cent of the determinations made will be in error by less than five per cent from the accepted molecular weight of salicylic acid, 138.

The following are some of the more obvious sources of error. If the walls of the test tube are so thick as to interfere seriously with rapid heat transfer the observed freezing point will be in error. Slow, cautious cooling will minimize this. Camphor tends to sublimate rather rapidly near its melting point. Keeping the tube well submerged in the bath, with rapid melting, will lessen the amount of sublimation. Inaccuracies in the weight of the solute or of the solvent obviously influence the quality of the results. Many instructors would prefer to issue tubes containing the weighed solute to the students, for this reason.

The writer wishes to thank his colleague, Dr. W. C. Thompson, for his suggestions in adapting this experiment to student use.

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[1] "Van Nostrand's chemical annual," 7th issue, D. Van Nostrand Co. Inc., New York City, **1934**, p. 816.

[2] RAST, *Ber.*, **55**, 1051, 3727 (1922).

APPOINTMENT OF INSTRUCTORS AT THE U. S. NAVAL ACADEMY

THE U. S. Naval Academy announces a vacancy in the Department of Electrical Engineering (Chemistry) for an instructor in first-year general college chemistry. The candidate must be a white, male, American citizen, not a member of the armed forces of the United States, and must have reached his twenty-fourth birthday, but not his thirty-first birthday on or before July 1 of the fiscal year in which appointed. He must be a graduate of, and must have had at least one year's experience in teaching and directing laboratory work in a college or university of recognized standing. The initial salary of an instructor is $2800 per annum.

Blank form of application may be obtained from the Superintendent, U. S. Naval Academy, Annapolis, Maryland, and must reach the Superintendent not later than April 14, 1941, accompanied by a photograph and such records, references, etc., as the applicant may wish to present.

NOTES ON SUGAR CHEMISTRY

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BECAUSE no other sugar was commercially available in practically unlimited quantity, the term sugar until recently has been almost synonymous with sucrose. The skyrocketing of the price of table sugar or sucrose during the first World War was the direct consequence of the lack of any satisfactory substitute, but now the price structure is materially changed by the daily production of hundreds of pounds of snow-white, crystalline glucose.

The consumption of sugar by the human race dates back to the dawn of history. The use of honey, milk, and fruits doubtless represents the form in which this carbohydrate material first became a part of the human dietary. Sugar cane was known in ancient China, India, and Egypt. As early as the seventh century A.D., sugar had already become a commercial product. In the fifteenth century the production of sugar cane became a part of a great American industry by its introduction into Brazil and the West Indies. About four centuries later, the extraction of sugar from beets marked another important advance in the American sugar industry, as evidenced by the fact that the sugar beet industry has now assumed commercial importance in the states of California, Colorado, Indiana, Kansas, Michigan, Montana, Nebraska, South Dakota, Utah, and Wisconsin, and is being produced in smaller amounts in some of the other states.

The sugar cane and the sugar beet industries were not sufficiently flexible during the last emergency to meet the sudden increase in demand, and forward-looking men of industry assigned research workers to the problem of producing crystalline glucose from one of America's first crops—corn. We have today, consequently, the technic, the capacity, and the raw material to produce a very satisfactory substitute for sucrose in almost any desired quantity in the form of crystalline glucose.

Other substitutes now commercially available are new sirups such as Sweetose and Liquid Sugar, and powdered products such as Dri-Dex, Fro-Dex, and Malto-Dextrine.

Among the newer derivatives of the sugars that are now available in semicommercial or commercial quantities may be included ethyl glucoside, glucose pentabutyrate, glucose pentapalmitate, glucose pentapropionate, and levulinic acid.

In the comparatively recent advances in the chemistry of the sugars may be included the analytical separation of various classes of sugars, a new ascorbic acid synthesis, some new glucose derivatives, hydrogenolysis of the sugars, irradiation of sucrose, the commercial production of lactic acid and its derivatives, the reduction of aldoses at the dropping mercury cathode, and the phenolic derivatives of D^+-glucose. Added to these should be the topics considered in the "Annual Review of Biochemistry," such as configuration of the pyranoid ring, Walden inversion, acetohalogen sugars, cleavage of ester linkages, mesyl derivatives, nitrates, phosphates, carbonates, chromatographic separations, ethylidene compounds, sugars in solution, ozonolysis, Weerman reaction, monosaccharides, disaccharides, and sugar acids.

The analytical separation of the various classes of sugars has been effected by Hurd and Cantor through complete ethylation, rectification, and identification of the fractions of the alkylated product. The technic has been extended to the identification of the constituents of corn syrup, and may be of value in following the degradation of the starch molecule. The qualitative identification of the natural sugars was outlined in detail by Militzer in the January, 1941, issue of this JOURNAL, and the determination of levulose in the presence of dextrose and sucrose is reported by Becker and Englis in the January, 1941, issue of the *Analytical Edition of Industrial and Engineering Chemistry*. D^+-Glucose and D^--fructose may be separated quantitatively, moreover, by the preparation of the azobenzene-*p*-benzoyl derivative.

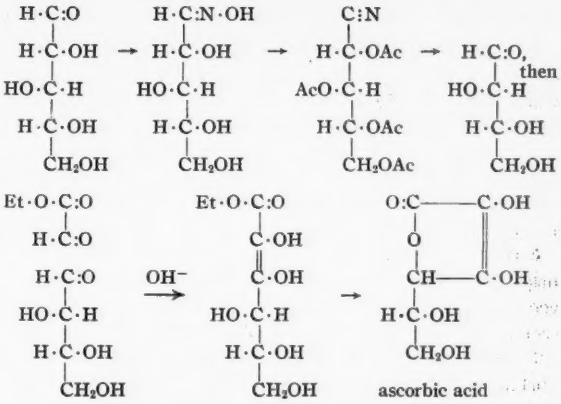
The hydrogenolysis of glucose has given *DL*-threitol, *i*-erythritol, anhydro-pentitol, hexanetetrol, and other products not yet identified.

The treatment of sucrose by irradiation in the presence of uranyl salts has resulted in the production of reducing sugars, which might suggest that the presence of reducing sugars in plants might be the result of either synthesis or degradation.

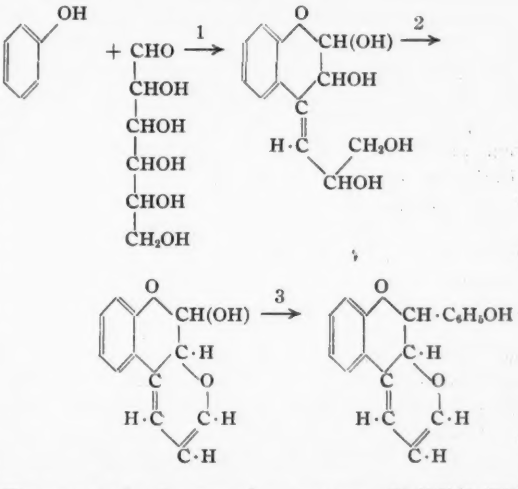
Lactic acid is being produced by the controlled fermentation of either glucose or lactose, and is available in tank-car lots as a food ingredient or as a synthetic intermediate.

Polarographic determinations, by the reduction of aldoses at the dropping mercury cathode, indicate that the free aldehyde content of a glucose solution is of the order of 0.03 per cent and that the rest of the sugar exists in the pyranose or ring configuration.

The Helferich and Peters synthesis of ascorbic acid (vitamin C) is indicated by the following series of reactions:



The condensation of the sugars of the reducing type with phenolic compounds, by Niederl and collaborators, gives some insight into the synthesis of the complex derivatives found in nature as indicated by the following equation:



The reagents for the successive steps are: (1) HCl/AcOH, (2) continued heating in the presence of HCl/AcOH with the loss of $2H_2O$, and (3) subsequent treatment with $C_6H_5·OH$. Subsequent condensations follow the same general course.

Sucrose octaacetate is now commercially available as a white crystalline solid, and finds use in certain types of adhesives, as a transparentizing agent for paper, as a plasticizer, and as a denaturant for rubbing alcohol. One part of sucrose octaacetate in 100,000 parts of water imparts a pronounced bitter taste.

Science Programs for Adult Radio Listeners

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SCIENCE, as a subject field for radio programs, is not new. Programs such as "The World is Yours," "Adventures in Science," "Hayden Planetarium," "Science Forum," and "Science in the News" are only a few excellent examples. These have been offered during the morning, afternoon, and evening: they have been directed to adults and toward in-school listening by children; they have utilized the talk, dialogue, and drama as program forms.

During 1939 the National Broadcasting Company alone reported 841 hours for "The Sciences." This was approximately one fifth of the total educational hours and approximately one twentieth of the total program hours. Since, in their listing, "The Sciences" embrace everything not included in the arts their classification is much broader than that used in this paper.

A recent examination of the program schedule of ten major stations in New York State for a sample winter week disclosed less than fifteen science programs, or an average of less than two per station per week; with but three exceptions all were supplied by the networks. This suggests that while science programs may be a very real part of the network's offerings, they still may not have reached the listener outside the service area of the key station of the network, if the local station fails to carry them. It also suggests that local science organizations are not attempting local science programs. As a matter of fact the situation is much the same as prevails with respect to health broadcasting. One of the authors made a comprehensive survey of 50 stations in New York State with respect to the latter a year ago last fall. It was found that most stations presented one health program per week; and that was usually supplied by the local or state health authority. The average is apparently much the same for science programs except that they seem to be supplied by the networks. When these former figures were released one private practicing physician sadly shook his head and added that one program per week had an enormous responsibility in counteracting the unusually large number of programs that recommend self-medication. The scientist might well wonder if the same problem, in a slightly different way, does not apply to him?

The evidence indicates that radio programs dealing with natural science are not uncommon. However, compared with other subject fields, such as religious and home economics programs, sports and news, political and general education programs, they are quantitatively a very small part of a listener's experience. This is even further emphasized by the current craze for quiz programs wherein science questions are seldom used. It is reasonable to suppose that while listeners are occasionally exposed to a science program, it is in about the same proportion as chlorine is added to water for bathing purposes, and the net effect is not as good. Educationally, the radio science program has a long way to go before the average listener is likely to take a more active interest or even to develop a curiosity about the progress of science from what he hears on the air. Possibly radio is not a good medium for stimulating or motivating an interest in science, but radio has generated an enormous interest in almost everything else, particularly current events, and one wonders if something more might not be done in the field of science—something perhaps that would encourage the lay audience to be more inquisitive about the natural world about them, to overcome superstitions, to know what the accepted fields of science are; and perhaps in a general way something to encourage the layman to know and adopt some of the procedures of the scientist in his approach to everyday problems. It was with these things in mind that the Technology Club of Syracuse, the Syracuse Section of the American Chemical Society, and the Science Division of the University set out to examine some program possibilities.

The first two of the above groups had urged for several years that some local science programs be broadcast from the Syracuse stations. Their request was formally presented to the Radio Workshop of Syracuse University and moral encouragement given to such programs which might be sponsored by the University. The preliminary plans for a science program were developed by the authors and presented for approval to the committee on broadcasting.

The Radio Workshop of Syracuse University thus inaugurated a science program which had some distinctive features, and under the title of "Ask the Scientist," the program first went on the air shortly after the opening of the school year of 1938–39. The program has been broadcast each Friday night during the last two years, 7:15–7:30 locally over WSYR, a basic Blue network station of NBC. A science board drafted from members of the science departments was selected to do the broadcasting. Members of the board were from the fields of chemistry, physics and astronomy, geology and geography, zoölogy, genetics and botany, and forestry. The chemist was selected as chairman of the board with no specific duties other than that of calling the board together once a week to go over the program and to assist in outlining the general order of the program when broadcast. The Director of the Radio Work-

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[1] Presented before the Division of Chemical Education at the one-hundredth meeting of the A. C. S., Detroit, Michigan, September 12, 1940.

shop represented the layman and read the questions which were to be answered.

It was emphasized from the beginning that this program was not for scientists but for listeners who knew little about science, and to accomplish this purpose it was agreed that there should be some form of audience participation. This did not mean participation by sending in questions for the sake of receiving money or other awards. A typical opening and closing continuity indicating the purpose of the program read as follows:

Opening: ASK THE SCIENTIST!

> The Radio Workshop on the campus of Syracuse University presents another in the series of programs called "Ask the Scientist." These programs are presented so that you in the radio audience may have answered those scientific questions which have you puzzled. On the science board tonight are:
>
> A chemist............................Albert Elder
> A zoölogist............................Verlus Lindeman
> A physicist............................William Fredrickson
> A forester............................Nelson Brown
> A geologist............................Sidman Poole
> A geneticist............................Ernest Reed
> And representing the radio audience......Kenneth Bartlett, and now once again we invite you to "Ask the Scientist."

Closing:

> You in the radio audience are invited to participate in this "Ask the Scientist" program. If you desire an answer to some question about science simply send a postal card or letter to the "Radio Workshop," Syracuse University, Syracuse, New York. Many of the questions received by the science board will be answered on the air. Those not on the broadcast will be acknowledged by mail. It is the purpose of this program to afford you the chance to get authentic answers to your questions about puzzling happenings in the scientific world. When a question occurs in your mind, we suggest that first you try to find the answer yourself. If you cannot, then we invite you to send us a postal card or letter and let the science board answer it for you. In this way we hope to encourage you to look at the natural world around you and learn more about how nature operates as it does.

From the continuity just quoted it is to be noted that the science board was particularly anxious to interest people in the scientific method.

It was the hope of the board that adults with little scientific training would become more interested in science. In this scientific age when so many developments of science are being used for the destruction of the human race, every avenue of approach which may lead to an appreciation of the true value of science should be utilized. Many people are actually afraid of attempting to do anything scientifically, and others have no idea of what is meant by the scientific method. Whether such a program meant for such an audience would have sufficient appeal to be self-supporting with respect to questions submitted, could only be answered by trying it out. Many friends advised us in advance that the program would be an absolute failure. They claimed that the radio audience was "not interested in science," that "no questions would be submitted," and that we "were foolish to present such a program without offering some compensation other than answering the questions over the air."

Such was the problem and the program. Now, after two years of broadcasting a science program directed by audience interests, it is the purpose of this paper to report a few of the things which the audience did and what its interests seemed to be.

Listeners responded by telephone, by innumerable contacts with the participants, and by letters. Five advertisers responded by making inquiry as to the commercial availability of the program, and three made definite offers. Colleagues occasionally criticized the program because it was "too simple" and "too light." When science crossed with tradition, we were told that we didn't know. We received among other things rocks, water, and bugs for analysis. A number of questions were asked about health and medicines despite our early refusal to include medical problems. Questions ranged out of the science field from life after death and economics to the family relationships of distant cousins.

Housewives were far more reasonable but they seemed to have an almost never-ending stream of questions about household economics such as: Is cooking in aluminum pots injurious? Will orange juice lose its value if kept overnight in the refrigerator? How can you keep piano keys from tarnishing? Is frozen milk injurious and can it be reheated? Will the more suds you have help purify water?

In the main, however, the mass of questions were fair, simple, and showed an honest desire on the part of the layman to know more of the natural world about him. We have taken 468 of the letters (this constitutes a definite sample of those received), and analyzed them to show:

(1) What fields were most frequently included.
(2) What proportion were from men, women, and children in school.
(3) What proportion were from cities and small towns.
(4) How many were poorly written and contained misspelled words.
(5) Sample letters that in a subjective sense were classified as typical and atypical.

Normally during a fifteen-minute broadcast the board answered an average of twelve questions. Every effort was made by the chairman to see that each field was equally represented. When the queries were analyzed we found that more questions concerned chemistry than any other field, with zoölogy, physics, and astronomy closely grouped.

The following indicates the proportion of inquiries to the number of fields.

Chemistry	39%
Physics and Astronomy	18%
Genetics	11%
Geology and Geography	10%
Zoölogy	10%
Forestry	9%
Non-Scientific Questions	3%

Twice as many letters were received from men as from women. Men were most interested in zoölogy, geology, forestry, and physics; women in botany and genetics. Chemistry was about equally divided between men and women. Of the children, almost all sent in questions that had perplexed their science teachers in high school. In a number of instances a full class would sign the letter.

The number of letters from cities with populations of over 10,000 was three times as great as from cities under that size. This figure is possibly meaningless, since the primary and consistent secondary service area of the station includes a population that is about three to one in favor of the city dwellers. At the most, it probably indicates that interest was about as great in rural as in urban areas. As for the letters themselves, they were about what one might expect from a general adult audience.

While no teacher of handwriting or commercial English teacher would pass most of those received, only eleven per cent contained misspelled words or were so carelessly written as to be difficult to read. If letters of this kind represent persons without education and in low income groups, then it can be said that they were the "lowest common denominator" and a comparatively small part of our audience. On the other hand about ten per cent had letter-head stationery and about ten per cent of the letters were typewritten. The number containing misspelled words balanced those that were typewritten.

Until a more careful analysis can be made we feel that the program was reaching its intended audience. To show the nature of their inquiries we would like to list some of the questions that seem fairly typical, and some of those that were atypical. Samples in the first group are:

> "In our chemistry class a discussion arose as to what was meant by the 'flotation process.' Will you please answer this question for me?"
>
> "Is water drawn from the hot water faucet harmful for drinking or cooking? The pipes are not lead, but of course there is an accumulation of rusty sediment in the hot water tank."
>
> "A kid from Montana says kerosene freezes at 55° below and a flashlight goes out at 50° below. Please tell me if that is so."
>
> "When water is heated it expands and when it is cooled it contracts. But when water is frozen it *expands*. Why is that so? Is this true of all liquids or just of water?"
>
> "I have been told on numerous occasions that tincture of iodine becomes unfit for use after it has been kept four or five years, even though it has been kept tightly corked. Would like to know if there is any truth in the assertion."
>
> "Last year we heard a scientist from the du Pont Company predict the increasing use in America of synthetic products. Since then I have heard that you can make buttons from milk, eyeglasses from wood, and silk hose from tin. Are these things possible and can you tell us the extent to which we are now using synthetic products?"
>
> "Will the distance from the ground up to the limbs lengthen as the tree grows or does it remain the same?"
>
> "Would your science board tell me whether there is any chance to grow sugar beets at all in this state? If they won't grow here, is it possible to develop some which will?"
>
> "Can two blue-eyed parents have a brown-eyed issue?" (Signed "an irate and questioning father.")
>
> "What causes the firefly's light?"
>
> "Is there such a thing called sex control? By that I mean can sex be determined in advance of birth? Could a couple have the sex of a child they wish to have?"

In the atypical group here are some of the more outstanding.

> "When a chemist makes an 'atom smasher,' how does he prove he can smash an atom with it, if you cannot see the atom?"
>
> "Would you be so kind to inform me if and how meat could be liquefied? I dissolved three ounces of meat in nitric acid, but that poison killed it all in all. I would like to dissolve three ounces of meat in a harmless preparation. Can you help me do this?"
>
> "There is a new drug for sexual weakness. What is the name of it and how expensive is it?"
>
> "I heard a story on the radio about a man who invented a machine which propelled him into the future fifty years. I know it was only fiction but it set me wondering how fast a man would have to travel to get into the future using time and space as a medium. If there could be invented such a machine could you explain say starting today, how fast would one have to go to reach tomorrow the same time?"
>
> "Now everything that grows has life, such as fruits, vegetables, flowers, and trees, etc. I know that there is a male and female among them. About stone or rocks there is big ones and little ones, then they must be growing too. There must be male and female among them. Please tell me how you could tell a male or female rock and how they mate?"

An unexpected outgrowth of the radio program was the suggestion by newspaper editors that it form the basis of a science column. The New York State Press Association offered this weekly service to its readers with the result that 107 local newspapers now carry "Ask the Scientist" as a weekly column. A recording is made of each program so that any challenges of statements made on the air can be checked against the records. The typed copy is approved by the scientist answering the question before being released for the press.

Our latest requests have been from other radio stations and from high schools. Other stations have shown an interest in the use of the recordings but to date we have not been able to release the only disc which we have in our own files. High-school requests must, for the time being, be turned down for the same reason.

In conclusion:

(1) Adult audiences are definitely interested in science programs.

(2) Wherever possible, every effort should be made to stimulate audience participation in the program.

(3) A greater effort should be made by local science units to provide science programs.

(4) Local science groups should encourage local stations to carry and not cut out science programs from the national hookups.

(5) Too large a proportion of the scientific endeavor of the world is being devoted to the destruction of the human race. Every effort must be expended in directing the thoughts of the people toward the utilization of science for the good of all rather than for mass destruction. This science program is but a single step in the direction of stimulating scientific thinking among our people.

High-School Chemistry

Demonstration of Electrolytic Extraction of Aluminum[1]

JOSEPH F. CASTKA *Boys High School, Brooklyn, New York*

ALUMINUM, the most abundant metal in the earth's crust, and probably the most important metal produced from its ore by electrolysis, is increasingly vital in industry and in the production of armaments. The story of the discovery of the method of production, by Charles Martin Hall, is one of the most inspirational of those a young chemistry student will encounter. The preparation of aluminum in a classroom demonstration should, therefore, prove of great interest.

The main practical difficulties have been the high temperature needed to fuse the electrolytic bath and the length of time needed to produce a sample that may be displayed to the class. The method described will show two simple procedures for fusing the bath. The time necessary for the entire demonstration is twenty-five to thirty minutes, and the experiment requires very little attention during the operation.

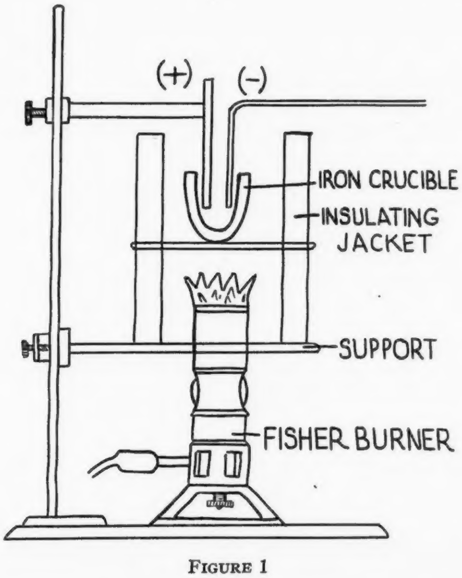

FIGURE 1

The first method for fusing the bath, shown in Figure 1, uses a modern Fisher burner and an insulating jacket made from a tin can about six inches high by five inches wide, lined with a one-inch layer of a 3 to 1 mixture of asbestos and portland cement. The bottom has been removed, and after hardening an insulating cylinder is produced that will maintain the temperature necessary for fusion of the bath. Two thin iron rods are inserted through the can and lining to furnish support for the crucible.

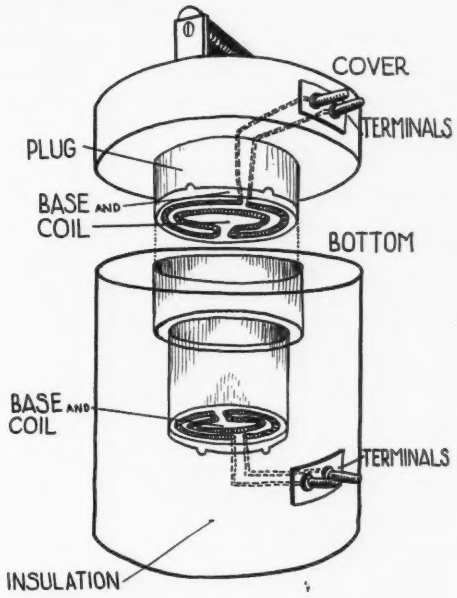

FIGURE 2

In industry the bath contains Al_2O_3 (10–25 parts), cryolite (90–75 parts), and fluorspar 36 per cent of the cryolite.[2] The eutectic point for a mixture of these materials is 868°C. and occurs when they are in the proportion 17.7:59.3:23. The bath used in the demonstration corresponds to the industrial proportions. An iron crucible of either 30- or 50-ml. capacity is used. The mixture is added, a teaspoonful at a time, until the crucible is one-third to one-half full of the fused mass. This takes from 10 to 15 minutes. The crucible should be covered between additions to hasten fusion.

The second and more convenient method of fusion

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[1] Apparatus exhibited at the Science Luncheon sponsored by the Science Council of Teachers of Science of New York City under the auspices of the Chemistry Teachers Club of New York, February 15, 1941.

[2] PARTINGTON, "A text-book of inorganic chemistry," 5th ed., Macmillan and Co., Ltd., London, **1937,** p. 875.

uses an easily constructed electric furnace. Two heating units, removed from a small electric stove, are used. These units consist of a refractory base, $3^1/_2$ inches in diameter, a nichrome coil using 575 watts, connected by 3 inches of asbestos-covered wire to a set of terminals mounted in a small refractory base about one by $^1/_2$ inch. A cylindrical can, 9 inches high and 7 inches wide, is cut off $1^1/_2$ inches from the top. The smaller piece will make the top and the larger the bottom of the furnace. Details of mounting each of the coils in the insulating lining are shown in Figure 2.

This lining consists of a mixture of 50 per cent asbestos and 50 per cent portland cement. The bottom of the furnace is lined with a $1^1/_2$-inch layer of the mixture; the coil and its base are placed on top of the bottom layer. The terminal part of the unit is connected to the coil by the asbestos-covered wire and is set in a small hole cut in the side of the can. The lining of insulating mixture is then continued to the top so that the diameter of the resultant oven is the same as that of the refractory coil base, $3^1/_2$ inches.

The upper portion of the can, $1^1/_2$ inches high, is then filled with the insulating mixture after the terminal part of the unit has been set in place through a hole in the side of the can. An additional plug, $3^1/_2$ inches in diameter, is built up to a height of one inch and the coil and its base set upon this. After the two parts have dried and hardened for about 36 hours, they are smoothed off so that the plug of the top fits rather securely into the cylindrical opening of the bottom, providing an oven space of about $3^1/_2$ by 4 inches to hold the crucible. After hardening, the heating coil of the top may be secured to the cover by a 3-inch bolt inserted through the center hole in the coil refractory. A handle may be connected to the projecting part of the bolt. The head of the bolt is covered with a small quantity of the insulating mixture to prevent heat loss. The furnace should be baked for two hours to make sure that all water is removed before operation.

A crucible is filled with the mixture and placed in the furnace. The terminals may be connected in parallel, or each one may be connected separately to an electric outlet by a plug such as is used for an electric iron. Fusion occurs within 15 to 20 minutes—a little longer than the gas method—but this process does not require continuous addition of materials.

The method of electrolysis is identical in both cases. The electrical furnace method is superior because of the ease of mounting and manipulating the electrodes. This is difficult in the gas method because of the open flame coming through the insulating cylinder. In industry an E.M.F. of 6 volts is used and each cell uses about 7000 amperes.[3] In the demonstration two storage batteries, arranged in series and furnishing 12 volts, are used. This should furnish a current of about 25 amperes. A switch and ammeter should be in the circuit.

After fusion, the cover is removed and the electrodes inserted, with the cathode a little shorter than the anode, to prevent short-circuiting through the crucible. An iron anode, $^1/_4$ inch in diameter, and an iron cathode, $^1/_8$ inch in diameter, are used, the latter conveniently made from a deflagrating spoon rod.

Upon electrolysis, a small molten pellet of aluminum, varying in size from $^1/_4$ to $^1/_2$ inch in diameter, is produced in from 10 to 15 minutes, and may be observed clinging to the cathode. When removed, the pellet develops a thin coating of white Al_2O_3 which is easily removed to reveal the characteristic aluminum color and luster. It is possible to keep the bath molten by the electrolyzing current alone during the electrolysis, but better results are obtained if the lower coil is kept in operation. Further amounts of the bath mixture or of Al_2O_3 may be added during the electrolysis if desired. These fuse easily. Care must be taken at all times to prevent a short-circuit through the crucible, for a hole will result; a flow of the molten mass into the heating coil will ruin the nichrome wire. If any difficulty is encountered in keeping the mass molten, an insulating plug may be made from the insulating mixture and the electrodes set in openings through this plug.

Attempts were made to use a carbon crucible and electrodes as is done in industry, but these did not prove satisfactory.

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[3] RIEGEL, "Industrial chemistry," 3rd ed., Reinhold Publishing Corp., New York City, **1937**, p. 303.

DEMONSTRATION OF EQUILIBRIUM

M. C. HAYS, of Lyons Township High School, LaGrange, Illinois, sends in the following demonstration of equilibrium in answer to a previous inquiry.[1] The demonstration is not new and will probably be recognized by some.

"A few ml. of an HCl solution of $SbCl_3$ are added to about 25 ml. of water in a beaker (400-ml. or larger). A white precipitate forms immediately, according to the equation:

$$SbCl_3 + H_2O \leftrightarrows Sb(OH)Cl_2 + 2HCl$$

When sufficient concentrated HCl is added, the precipitate dissolves. The point of equilibrium may be changed by the addition of either water or concentrated HCl, and the class can easily see the effect of concentration in an equilibrium reaction."

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[1] J. CHEM. EDUC., **17**, 346 (July, 1940).

LETTERS

A Chemical Pioneer in High-School Teaching

To the Editor:

Dr. Brandt V. B. Dixon, for long years the President of Sophie Newcomb College, New Orleans, once told me of his early experiences in teaching high-school chemistry by the laboratory method. It seems to me that a publication of his own words on this subject might bring forth reminiscences from other people. Any comments will probably come from men of real maturity, for Dr. Dixon is now past ninety years of age.

> "The first chemical laboratory of high-school grade in the United States was probably started by myself in St. Louis. In 1873 I became a teacher of chemistry and physics in the St. Louis Central High School, then situated on Fifteenth and Olive Streets, and was personally ambitious to develop as a chemist.
>
> "I secured a good classroom table and some apparatus, but could not persuade the Board of Education to admit laboratory teaching. I therefore started to equip a laboratory for myself in a downtown room and to solicit analytical business. In a year or two I was beginning to succeed, working after school hours, Saturdays and holidays.
>
> "In 1875 a group of upperclass boys asked for laboratory training and I took them as a volunteer class once a week, after school. Their enthusiasm and success, even with the few appliances we had, led the Superintendent, William T. Harris, later of national fame in the field of education, to endorse my plea for a laboratory. This laboratory was installed in the school basement, September, 1876. So far as I can learn, this was the first high-school chemical laboratory in the United States. The appropriation granted was $5000."

HARRY N. HOLMES

OBERLIN COLLEGE
OBERLIN, OHIO

What Is an Element?

To the Editor:

It occurs to me that it is about time we redefined the chemical term *element*. Not so long ago the definition ran something like this: "An element is a simple, undecomposable substance." The discovery of radioactivity and, later, of the "artificial" disintegration of elements forced a modification of that expression. The popular expression for a while, which I remember having been taught—indeed having myself taught—was that "An element is a substance which cannot be broken down into anything simpler by *chemical* means." But this was a circular definition; for we allowed no method to be called a chemical one which was capable of disintegrating an element. The present vogue seems to be (although I am not quite up to date on elementary textbooks) somewhat in the sense of the following: "An element is a substance which cannot be broken up into simpler substances by *ordinary* means." Now this definition is not only a circular one, it is vague, and it is doubtfully truthful; for the methods by which elements may be decomposed have become ordinary enough, in all conscience!

The definition which I should like to propose may be stated in the following manner: *An element is a substance of the second* (perhaps the third) *order of complexity*. Classified as belonging to the *first* order of complexity, I should lump together all those delightfully vague and intriguing entities such as protons, neutrons, electrons, positrons, mesotrons, neutrinos, etc., *ad infinitum*. But perhaps this group should have been separated into two parts, since it appears that protons and neutrons, at any rate, are complex. In that case, electrons *et al.* would appear as substances of the first order; protons and neutrons of the second order. Chemical compounds would then be substances of the fourth (or third) order of complexity. I do not know whether or not, under this system, some of the coördination compounds might deserve rank as of a higher order. At any rate the system is accommodatingly flexible.

Although I am not aware that anyone has previously proposed such a system of definitions, the idea is so simple that it would not be surprising if someone had done so.

E. C. PAYNE

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ELMHURST, ILLINOIS

Symbols or Abbreviations?

To the Editor:

I was interested in the letter of C. E. Ronneberg on page 44 of the January, 1941, number of your JOURNAL. The reference to the 1879 recommendation of the International Committee on Weights and Measures pleased me although it goes back to before my time. I didn't realize that the *millimicron* was given its preferable abbreviation as long ago as that.

The abbreviations given please me except in a few cases. *Chemical Abstracts* has, during the last four decades, done much to accomplish uniformity in chemical nomenclature. It has from time to time printed *Directions for Assistant Editors and Abstractors*, of which the 1939 number is the latest. The *Directions* do not call for dropping the period after the 14 abbreviations listed. Although my experiences do not go back as far as 1879 in the Public Schools of Boston, they started soon after this, and we were always required to use the period. Lately there was been an increasing tendency to drop the period and the "Office Editor" of some of my own books has done it quite recently. With respect to two of the abbreviations, *Chemical Abstracts* is definitely opposed and I am positive that they do not conform to modern usage in most well written texts on chemistry. I refer to cm^3 and cm^2. Our *Directions for Assistant Editors and Abstractors* emphatically require cc and sq. cm.

Personally, I read about one thousand scientific papers every year and I feel sure that a return to the 1879 recommendation is not advisable at this time. Chemists have been *writing* cc and *saying* cc for at least 40 years and I can see no advantage to be gained by returning to cm^3, which was never really adopted by a majority of chemists. As Mr. Ronneberg admits, the abbreviation ml is better anyway. Yet it is remarkable that the error in the attempt to make the liter exactly one cubic decimeter is only 27 parts in one million. I wish I could work as accurately.

WILLIAM T. HALL

SNIPATUIT ROAD
ROCHESTER, MASSACHUSETTS

Mnemonics

To the Editor:

May I be allowed to add the following two mnemonics to your steadily increasing list? The essence of Vörlander's Rule concerning the directing influences of substituents in the benzene ring is that a substituent containing a *D*ouble bond directs *M*eta and that a substituent which contains only *S*ingle bonds or which consists of a *S*ingle atom directs *O*rtho and *P*ara. "DAM SOP" therefore summarizes the Rule.

In order to remember that the sixth, eighth, and tenth members of the fatty acid series are caproic, caprylic, and capric acids and in this order, it is noted that the second vowels of the three words are *o*, *y*, and *i*—memorized as "Oh my eye."

H. H. HATT

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MELBOURNE, AUSTRALIA

Atomic Weight Units

To the Editor:

In connection with Fred Fordemwalt's question "Why hasn't the unit of atomic weights been given a name?" [J. CHEM. EDUC., **17**, 545, (Nov., 1940)], the following quotations from "Chemistry—An Elementary Text-book," by MORGAN AND LYMAN, (The Macmillan Co., New York City, **1913**, pp. 106–7) may be of interest:

> "According to Dalton's theory, combining weights are simply the weights of the atoms of the different elements; *i. e.*, the atomic weights. We should remember, however, that the idea of atomic weights is part of a theory only. . . That each element has a reacting weight is a fact, however, that will stand as long as there is any science at all.
>
> "In determining the relative weights of the atoms of different elements, the weight of the hydrogen atom was taken as 1. The weight of the hydrogen atom is often called a microcrith. . .
>
> "On the basis of oxygen 16, speaking accurately, we should have to define a microcrith as $^1/_{16}$ of the weight of the oxygen atom and say that the hydrogen atom weighs 1.0075 microcriths."

The present writer, however, believes it is confusing to call a ratio of two weights a unit. To talk in terms of a microcrith gives one the feeling that he is talking about a definite unit.

LAWRENCE E. WILKINS

UNIVERSITY OF SOUTHERN CALIFORNIA
LOS ANGELES, CALIFORNIA

NOTE ON THE BREAKING OF PYREX FLASKS[1]

HAROLD A. WOOSTER
University of Wisconsin, Madison, Wisconsin

SEVERAL 2-liter pyrex Florence flasks were broken while preparing CO_2-free distilled water by boiling with a Meker-type burner. Since the double precautions of a heavy wire gauze and boiling chips were used, these breakages were theoretically, as well as practically, annoying. An attempt to break by drastic heating of 300-ml. pyrex Florence flasks, filled with water, was then made. The inner cone of an M.I.T. blast-lamp, played on the unprotected bottom of these small flasks, would boil the water contained therein, with no fractures. The same flasks, placed on a wire gauze and heated with the same flame, would break after about three minutes of heating.

A disappearing-filament optical pyrometer was used to determine the temperatures of wire gauzes heated with several different types of burners. (This instrument is calibrated for black-body radiation. Since the emissivity of iron oxide is 0.98, the error of the instrument from this source is small.)

The following values, which are the temperatures of a gauze heated in the flame, and not necessarily flame temperatures, were obtained:

Blast-lamp	1300°C.
Fisher burner	1080°C.
Meker burner	1080°C.
Bunsen burner	970°C.

The International Critical Tables give the "softening temperature" of pyrex glass as 850°C. It would seem probable that the wire gauze presses several points at an even higher temperature against the glass, causing cracking in the same way that a piece of hot glass may be used to crack tubing. This was checked by using the end of a small file, curved and clamped against the bottom of the water-filled flask so that only the end of the file pressed against the glass. When this flask was then heated by a Fisher burner, it would crack. A control flask, heated with the same burner, but without the point of hot iron pressed against it, would boil the water without breaking the flask.

By supporting the flasks to be heated about 2 cm. above the gauze, so that it serves merely as a source of radiant heat, it is possible to use the full flame of a Meker-type burner without cracking the flask. When this is impossible, it is desirable to use a gauze with an asbestos center.

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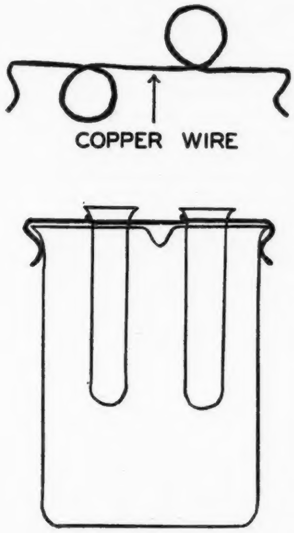
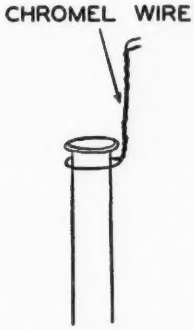
[1] This work was done while the author was holding a scholarship from the Wisconsin Alumni Research Foundation.

Out of the Editor's Basket

Sister Eleanor Marie, of Chestnut Hill College, Philadelphia, writes us to describe the many advantages in saving of time and money, and increased interest and success in qualitative analysis which they have enjoyed at that school since the introduction of semimicro technic. Her report so nearly parallels those made from other sources that we have not felt able to publish it completely. Two particularly ingenious bits of apparatus were described, however, which we reproduce here. The first of these, shown in the accompanying illustration, is a water bath for micro-size test tubes, made from a 250-ml. beaker and a little heavy copper wire. The other is a way of adapting the 4-ml. test tubes to use in the ordinary centrifuge head, by supporting them with a few twists in a short piece of chromel wire.



Water Bath



Support for Test Tube in Centrifuge Head

● It seems incredible that with all the work that is just crying to be done in this world so many people should be idling around with nothing to do. The American Youth Commission has reported that 80 per cent of the high-school youngsters enrolled last summer in the first organized work camp program had never before done any type of real manual labor. Few knew how to handle tools. "Fingers were nicked and blisters were worn in their first clumsy efforts at work," say the authors of the report. One of our friends in a very large city told us some time ago that he had observed that perhaps the principal problem of the high schools was to teach the dignity and respectability of labor. The chief ambition of youngsters seemed to be "to grow up and get on Relief like father."

● The National Federation of Business and Professional Women's Clubs, interested in the vocational progress of women, publishes each month in its magazine, "Independent Woman," an article on some field of work. These articles are reprinted in a series, "Vocations for Women" (15¢ each, from the office of the Federation, 1819 Broadway, New York City). One of these—"Success from Test Tubes"—which has just come to us, describes the profession of chemistry from the woman's angle. Young women, contemplating a career in chemistry, will get good advice from it, and just the proper measure of encouragement.

● It has been pointed out that while natural rubber is still one of the best all-around engineering materials known, it is inferior to synthetic rubbers in resistance to certain influences often encountered in service. These are (1) swelling and deterioration in contact with oils, organic solvents, and water, (2) cracking in sunlight, (3) deterioration by heat, (4) powerful oxidizing agents, (5) diffusion of gases. But natural rubber is still superior to all present synthetics in (1) elasticity and rebound, (2) low heat generation through hysteresis or internal friction, (3) extensibility, (4) resistance to stiffening at low temperatures. While this is the picture today, it may change even in the next few months.

● Another development in the rubber industry is said to be the use of a new type of carbon filler which increases the electrical conductivity of rubber enormously, so that static charges, which often produce serious effects, are dissipated harmlessly.

● It is surprising how much sound, interesting, and up-to-date chemical information can be had from the many "house organs" that appear regularly. What brought this to mind was a glance at "Pittsburgh Plate Products," issued by the Pittsburgh Plate Glass Company. This is only one of a dozen we could name in one breath, and teachers are missing an opportunity to keep abreast of the times by not asking to have their schools or themselves put on the mailing lists. Start with the list of our advertisers, and don't forget to mention the Journal.

● We have received a little pamphlet (price 25¢) entitled, "Dangers and Health Hazards of Fire Gases," written and published by Harold J. Davis of 3927 East Admiral Place, Tulsa, Oklahoma. It contains a number of useful points about the action and behavior of fires, the reactions of materials under fire conditions, and substances capable of producing lethal gases. The chemistry contained is of the very simplest, but it would be useful to have around in any laboratory.

● Some figures recently supplied by the American Association of Junior Colleges may be of interest. It seems that the number of junior colleges in the country is now 610, enrolling 236,162. Increase in enrollment was 20.5 per cent during the last year, nearly as much as the increase the preceding year. Only 195 colleges have more than 300 students, 46 have more than 1000, and 18 more than 2000. Most of the largest institutions are in California.

Junior colleges are found in 44 states, only Nevada, Wyoming, Rhode Island, and Delaware being without any. The ten states leading in numbers are: California, 64; Texas, 43; Iowa, 36; Oklahoma, 30; North Carolina, 25; Kansas, 24; Missouri, Illinois, Pennsylvania, 24; Massachusetts, 23. Forty-three per cent of the junior colleges are publicly controlled and have 71 per cent of the enrollment.

● Here's a suggestion for illustrating the relations in structural isomers in a simple way: RAT, TAR, ART.

RECENT BOOKS

THEORETICAL QUANTITATIVE ANALYSIS. *L. Waldbauer*, Ph.D. Associate Professor of Chemistry, State University of Iowa. First Edition. The Blakiston Company, Philadelphia, 1940. x + 248 pp. 37 figs. 15 × 22 cm. $2.75.

According to the publishers, "This book presents material for a two-semester course in quantitative analysis for sophomores." The topics are: atomic and molecular structure; errors, significant figures and computations; analytical calculations; activity; precipitation; oxidation and reduction reactions; volumetric standards; voltaic cells and electrode processes; origin of the electromotive force; standard electrodes; oxidizing potentials; electroanalysis; indicators; buffer solutions; recent advances; applications of the theories in practice.

The section on computations is logically developed and well supplied with illustrative problems. However, the value of introducing *titre*, especially before *normality*, is questionable in such a book, and the use of m for molarity (mols/l.) and M for molality (mols/1000 g. solvent) introduces the student to an unusual symbolism.

The employment of activity coefficients is commendable, and could be useful to the sophomore analyst. Unfortunately, although the hands are those of Debye and Hückel, the voice is that of Arrhenius, when the author explains the increased activity coefficient of HCl in concentrated solutions wholly in terms of hydration.

The text introduces casually and without definition such important terms as *ionic strength* (p. 98), *free energy* (p. 111), and *isoelectric point* (p. 114), which can hardly be familiar to sophomore readers. A failure to describe other important concepts clearly or adequately is due in part to their premature introduction, which could be avoided by a different sequence of topics. *Oxidizing potential* (p. 143) is defined with no reference to the hydrogen scale introduced under standard electrodes (p. 172).

A number of defects in choice, arrangement, and treatment of material detract from the usefulness of this book, in comparison with the more complete theoretical discussions to be found in nearly all modern texts on quantitative analysis.

FRANK T. GUCKER, JR.

NORTHWESTERN UNIVERSITY
EVANSTON, ILLINOIS

CHAMBERS'S TECHNICAL DICTIONARY. *C. F. Tweney* and *L. E. C. Hughes*, Editors. The Macmillan Company, New York City, 1940. vi + 957 pp. 13.5 × 20.5 cm. $5.00.

This new and authoritative, yet handy, work of reference contains thousands of terms drawn from about a hundred branches of scientific and technological activity. Some of the main fields covered include acoustics and sound recording, aeronautics, astronomy, botany, building and construction, electric communications, engineering, geology and mineralogy, horology, illumination, medicine, surgery and veterinary science, metallurgy, meteorology, mining, photography and cinematography, physics and chemistry, printing and typography, radio and television, textiles and allied trades, zoölogy.

STATISTICAL THERMODYNAMICS. *R. H. Fowler* and *E. A. Guggenheim*. The Macmillan Company, New York City, 1940. x + 693 pp. 17.5 × 26.5 cm. $9.50.

Pure thermodynamics is a powerful tool but its application requires data which are sometimes difficult to obtain from experiment. Great progress has been made in physical chemistry because statistical mechanics has made it possible to compute precise values of certain thermodynamic functions from existing information and so supplement direct measurement.

STATISTICAL THERMODYNAMICS is a book intended to bridge the gap between pure thermodynamics and pure statistical mechanics. For those who have not the time or inclination to study the detailed mathematical treatment there are many long discussions which can be read with much profit. The book is not one, however, to be mastered entirely by a casual reading. Even for a thorough student of pure thermodynamics, mastery of all of the material in this book will require some intensive study.

The subjects discussed at length include gases, crystals (including lattice imperfections), chemical equilibria and evaporation, liquids, solutions of non-electrolytes and of electrolytes, surface layers, electron theory of metals, chemical kinetics, and electric and magnetic properties. Though chemical kinetics admittedly is not thermodynamics, its inclusion in this book, written especially for students of physics and chemistry, is appropriate and welcome.

A characteristic feature of the book is the detailed discussion that accompanies the introduction of a new definition, concept, or important theoretical conclusion. Though there is little attempt to correlate theory with experiment, these interpretations of the meanings and implications of the theory will assure the book an extensive and most appreciative audience.

T. F. YOUNG

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CHICAGO, ILLINOIS

THORPE'S DICTIONARY OF APPLIED CHEMISTRY. Volume IV. *J. F. Thorpe* and *M. A. Whiteley*. Fourth Edition. Longmans, Green and Co., Inc., New York City, 1940. xxiii + 603 pp. 15 × 23 cm. $25.00.

In this volume, treating subjects from Digallic Acids through Feeding Stuffs, the policy is continued of combining the dictionary style with the use of the monograph where such treatment seems suitable. The monographs are for the most part self-contained and combine a history of the subject with a concise account of its modern position. The main object of the dictionary is "to present to the general chemist and the expert alike a summary and account of the present day position of chemical science, and to enable them to find, couched in as simple language as possible, a description of all that may be included in that term." The volume is well printed and illustrated.

THE MEANING OF MATHEMATICS. *C. J. Keyser*. Scripta Mathematica, New York City, 1939. 28 pp. 13 × 19 cm. $0.25.

AN INTRODUCTION TO ORGANIC CHEMISTRY. *I. D. Garard*, New Jersey College for Women, Rutgers University. Second Edition. John Wiley and Sons, Inc., New York City, 1940. xi + 389 pp. 16 figs. 15 × 23 cm. $3.00.

This edition is nearly a hundred pages longer than its predecessor. Thirty-one experiments are listed in the last 40 pages of the book. It is still intended, however, as a text for a one-semester course in the subject. In general the presentation is clear and orderly.

The author's point of view is expressed in the preface: "It is felt that a rather thorough study of a small field is preferable to a scant treatment of all the topics that are introduced into a course which extends throughout the year." Such restraint is commendable. Generally, the author has succeeded in carrying out this aim but one wonders what guided his preference in devoting four pages to purines and pyrimidines, another four to a detailed list of the several amino acids obtainable from proteins, two pages to the "table of contents" type of treatment of simple, conjugated and derived proteins, one page to terpenes, apparently to show their complexity, yet only one sentence to Grignard reactions. Most of the topics generally found in larger texts are treated in this book (the statement in the preface notwithstanding) but these items are omitted: acetoacetic and malonic esters, nitroparaffins, organic compounds of arsenic and phosphorus. For the most part Professor Garard's presentation, although not particularly novel, has been well done. Teachers may use it with the knowledge that facts in it are well presented, that good nomenclature usually prevails, and that considerable attention is paid to reactions which are of modern industrial importance.

CHARLES D. HURD

NORTHWESTERN UNIVERSITY
EVANSTON, ILLINOIS

AN INTRODUCTION TO CHEMICAL SCIENCE. *W. H. Hatcher*, Professor of Chemistry, McGill University. John Wiley and Sons, Inc., New York City, 1940. v + 423 pp. 66 figs. 14 × 21.5 cm. $3.00.

This text is written to meet the needs of the student who does not intend to enter the more advanced chemistry courses for professional training. It is well adapted to the needs of those students who desire a cultural background of chemistry in its application to everyday life. In this connection the text is admirably suited for physical science survey courses.

The book is divided into four main units as follows: (1) Inorganic Chemistry, (2) Organic Chemistry, (3) Food Chemistry, (4) Industrial Chemistry. A relatively large portion of the text is devoted to the first unit; however, the other units are adequate for the non-professional student. It is assumed that the text will be supplemented by lecture demonstrations rather than by laboratory work. The book is very well written and stimulating.

WARREN C. JOHNSON

UNIVERSITY OF CHICAGO
CHICAGO, ILLINOIS

OFFICIAL AND TENTATIVE METHODS OF ANALYSIS OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS. *W. W. Skinner, E. N. Bailey, L. E. Warren, J. W. Sale, G. G. Frary, H. A. Lepper*, and *M. E. Lapp*, Editors. Fifth Edition. Association of Official Agricultural Chemists, Inc., Washington, D. C., 1940. xii + 757 pp. 61 figs. and 25 reference tables. 15 × 23 cm. $5.00.

"The most valuable contribution made to agriculture in the last forty years has been that of the standardization of the chemical and physical methods of research in agriculture by this Association." The continuation of this purpose results in the Fifth Edition of the Official Methods, which has been kept to a convenient handbook size and yet contains new material, including Fish and Other Marine Products, Vitamins, Microbiological Methods, and Microchemical Methods. Its value is an accepted fact; its content has been brought up to date, and it will be a necessary reference book for the working chemist.

PHYSICAL CHEMISTRY. A BRIEF COURSE WITH LABORATORY EXPERIMENTS. *L. J. Bircher*, Professor of Physical Chemistry, Vanderbilt University. Prentice-Hall, Inc., New York City, 1940. xvi + 429 pp. 75 figs. 15 × 23 cm. $3.00.

Another author attempts the difficult task of writing a textbook which seeks to give students, majoring in chemistry and chemical engineering, a brief introduction to physical chemistry in the intermediate college years, and also to meet the needs of students who are preparing "for medicine, biology, geology, agriculture, and other branches of engineering."

It is improbable that any two teachers of physical chemistry could be in agreement as to the selection of topics for such a course and the particular emphasis which should be given. The statement by the author of his basis of selection suggests a somewhat new approach to the problem. "The materials particularly selected are those which show how atomic structure and certain forces control solubility and chemical reactivity—two factors important in all of these sciences. This material and certain other topics that are included should serve as a background for advanced work in chemistry or for those other sciences in which chemistry plays an important part. Each part of the book stresses a phase of the problems of solubility and reactivity. Part I deals with the role played by atomic and molecular structure; Part II discusses the property of substances called *fugacity*, which is related to gas and vapor pressure and which is a controlling factor in chemical reactivity; Part III deals with reaction velocity and with the methods used to measure chemical reactivity." Detailed directions for a series of twelve laboratory experiments are given in Part IV. Questions for review and discussion together with a few problems are given at the end of each chapter.

The treatment in general is non-mathematical and no knowledge of calculus is assumed. In choice of material and development of the subject there is little that is unusual with texts of the kind; the difference in approach seems to be more a matter of terminology than of content or method of treatment. The concept of fugacity is particularly useful in the accurate quantitative description of a system and the emphasis on fugacity in a textbook which is largely descriptive and non-mathematical is of interest to the teacher but of doubtful value to the student. The chapters on Free Energy, Thermochemistry, and Thermodynamics are very satisfactory but that on Reaction Velocity seems far from adequate. With the emphasis on the modern concepts of acids and bases in many of the recent general chemistry textbooks it would seem that the time has come to make a thorough revision of the treatment of electrolytic solutions in elementary physical chemistry.

The material is presented clearly and the book is distinctly readable. For courses designed to give students of other sciences an elementary knowledge of physical chemistry the book is admirably adapted.

EMMA P. CARR

MOUNT HOLYOKE COLLEGE
SOUTH HADLEY, MASSACHUSETTS

LABORATORY AND WORKBOOK UNITS IN CHEMISTRY. *M. U. Ames*, George Washington High School, and *B. Jaffe*, Bushwick High School. Consumable Edition. Silver Burdett Company, New York City, 1940. xx + 267 pp. 37 figs. 19.5 × 24 cm. $0.92.

The material in this manual is divided into fifty-one units, consisting of Experiments, Observations and Questions on the Experiments, and Conclusions. The instructions for each experiment are simple, clear, and specific and the student is aided in making a concise record of what he has seen and done. After each experiment the student makes generalizations based on his own recorded observations. Supplementary Exercises and Optional Questions require application of principles developed in both laboratory and text, and provide a means of allowing the more gifted student to go on with his learning, while the poorer one still completes the required work.

Laboratory Manual of Elementary Organic Chemistry. *G. H. Richter*, Assistant Professor of Organic Chemistry, The Rice Institute. John Wiley and Sons, Inc., New York City, 1940. ix + 128 pp. 12 figs. 15 × 23 cm. $1.25.

The manual is designed for a full (not semester) course in elementary organic chemistry and is intended to appeal to the interest of students specializing in the biological fields. The choice of experiments involving both technic and type preparations is good. A number of medicinals are included but are not chosen solely for their interest as such. The teaching of fundamental organic chemistry has not been subordinated to the special aim; it would appear that the author has admirably carried out his purpose.

The introduction to the manual is excellent both as to first-aid suggestions and instructions for the writing of laboratory reports. The reviewer wishes to add his testimony to the value of preliminary reports on synthetic preparations which "should be completed before the student enters the laboratory."

The first six experiments deal principally with preliminary tests and technic; experiments 7–24 with aliphatic syntheses; experiments 25–47 with aromatics; and experiment 48 with the isolation of caffeine. A short valuable section on the literature of organic chemistry and a reagent list for each experiment are included.

The manual is well balanced in including (1) preliminary tests, (2) experiments illustrating typical technics (vacuum distillation, etc.), (3) typical classical reactions (Grignard, Sandmeyer, Friedel-Crafts, etc.), (4) synthetic sequences, (5) qualitative tests (Hinsberg separation, etc.), and (6) the preparation of compounds of special interest (anesthesine, phenacetin, sulfanilamide, etc.). It is unfortunate that a few alternate experiments are not given for a part of the medicinal preparations, as the manual would then also serve equally well for a general introductory course. Minor suggestions, which might increase the value of the manual somewhat, would be the inclusion of the time required for each experiment and a summary of total amounts of materials required for the course.

The book is bound in paper with a spiral binding.

Osborne R. Quayle

Emory University
Emory University, Georgia

Physical Chemistry of High Polymeric Systems. *H. Mark*, Polytechnic Institute of Brooklyn. Translated from the manuscript by *K. Sinclair*, revised by *J. E. Woods*, Queens College. Volume II of the monograph series on High Polymers. First Edition. Interscience Publishers, Inc., New York City, 1940. x + 345 pp. 99 figs. 15 × 23 cm. $6.50.

High polymers have, of course, been known since the early days of chemistry, but the chemistry and physics of high polymers are, for all practical purposes, developments of roughly the last decade. Their complexity made them unattractive subjects for academic research, while in the technical field, research was largely aimed at the development of new polymeric substances for specific purposes, rather than at an understanding of their structure and properties. Gradually, however, thanks to the efforts of a few pioneers who had the courage to tackle what seemed to be a hopelessly intricate set of problems, some of the fundamental questions regarding formation of macromolecules were solved, and a beginning was made in the correlation of the observable properties of polymeric systems with their molecular structure. Synthesis and determination of structure is primarily the task of the organic chemist; the second group of problems is essentially the field of the physical chemist.

Professor Mark's book has a twofold purpose: first, to summarize the methods of physical chemistry which may be applied to the field of high polymers; and second, to sum up and critically review what has been accomplished to date in such application. Many of the methods which the author discusses have not yet been applied to high polymers, or else their application is still in the preliminary stages; the inclusion of many suggestions of problems yet to be investigated is one of the most valuable features of the monograph.

The section on determination of structure by X-rays and electrons might, in the reviewer's opinion, have been improved by the inclusion of some diagrams, with appropriate discussion, for several of the high polymers which are now known fairly well. Likewise, the plasticization of polymers might well have been mentioned in the treatment of secondary valence. The chapter on electrical polarization is necessarily brief, but space could have been found to include a short discussion of the Onsager field. The whole section is based on the Clausius-Mosotti equation, which implies the Lorentz field, and hence applies only to gases or dilute solutions in non-polar solvents. The statistical treatment of the configuration of a chain molecule is excellently presented, and due emphasis is placed on the importance of fluctuation terms. In the chapter on the thermodynamics of solutions, the discussion of higher terms in concentration in the law of osmotic pressures merits attention not only from workers in this particular field of high polymers, but also from teachers of physical chemistry. Incidentally, it seems appropriate to mention the fact that the application of many of the accepted notions of physical chemistry to substances of high molecular weight has led to a critical re-examination of the postulates, approximations, and assumptions involved; this is particularly true for the colligative and hydrodynamic properties of solutions.

It is impossible to give an adequate review of this book without mentioning the fact that it is the second one of a series of monographs on high polymers. Many subjects, for example, viscosity of solutions, which are only summarized in this volume, will be treated in detail in later publications. A possible third purpose of this book is to serve as an introduction for subsequent monographs; certainly it will prove to be very helpful to those who are interested primarily in one specific field of high polymers, but who would like a comprehensive and yet condensed account of their physical chemistry. Indeed, entirely apart from its place in the field of high polymers, the book might well be used as a reference or advanced text for physical chemistry in so far as its application to molecular structure and behavior is concerned.

Raymond M. Fuoss

General Electric Company
Schenectady, New York

Electrochemistry and Electrochemical Analysis. *H. J. S. Sand*, D.Sc., Ph.D., F.I.C. Two volumes. Chemical Publishing Co., Inc., New York City, 1939–40. Vol. I, viii + 133 pp., 9 figs. and 1 plate. Vol. II, ix + 149 pp., 46 figs. 12 × 19 cm. $2.00 per volume.

Volume I. *Electrochemical Theory.* Includes a discussion of electrolysis, the ionic theory, the conduction of the current in the interior of the electrolyte, applications of the law of mass action to the ionic theory, electromotive force and heat of reaction, activity—theories of interionic attraction, electrode potentials, liquid junction potentials, irreversible electrolytic processes, polarization, structure of electrolytic deposits. The exposition frequently deviates from that usually found in current textbooks on the subject.

Volume II. *Gravimetric Electrolytic Analysis and Electrolytic Marsh Tests.* Particular attention is given to the methods for separating metals by control of the cathode-potential with the aid of an auxiliary electrode, as simplified by Lassieur by the introduction of what may be described as high-resistance voltmeters in place of the potentiometers previously used. The brief explanatory characterization of each metal, given in the chapter dealing with prescriptions for quantitative deposition, helps to coördinate the practice of analysis with an appreciation of physico-chemical principles.

Science for Handicraft Students. *H. Morton*, B.Sc., A. Inst. P. Chemical Publishing Co., Inc., New York City, 1940. 149 pp. 156 figs. 13.5 × 21.8 cm. $3.00.

This textbook for handicraft students of all types deals with the application of the scientific principles of mechanics, hydrostatics, chemistry, and electricity to everyday life and especially to workshop practice in wood and metal.

NICHOLAS D. CHERONIS

Organic Chemistry

An INTRODUCTION to the CARBON COMPOUNDS

☞ **by Nicholas D. Cheronis, Chicago City Colleges**
728 pages, 6″ x 9″, $4.00, Published April, 1941

THE usual course in organic chemistry all too often becomes for the beginning student an array of formulas, preparations, and reactions of one group of compounds after another. In this new textbook an attempt is made to minimize this difficulty by providing a clearer organization of factual material than has yet been available. Thus an important feature is the early introduction (Chapters 14 and 15) of new material for the correlation of facts thus far presented and also a review of the theoretical aspects already discussed. The value of this whole method of approach has been demonstrated by several years actual experience with experimental mimeographed editions.

BABOR and LEHRMAN

Introductory College Chemistry

☞ **by Joseph A. Babor and Alexander Lehrman,**
College of the City of New York
650 pages (approximate), 6″ x 9″, $3.50
Ready April, 1941

A NEW book, replacing ELEMENTS OF GENERAL CHEMISTRY by Babor, Estabrooke, and Lehrman. It is intended for two types of courses: (1) those composed of students who have *not* had high school chemistry and (2) those where no differentiation is made between students having had a chemistry course and those who have not. It is a companion volume to GENERAL COLLEGE CHEMISTRY by the same authors and should enable students to compete successfully in advanced courses with students having had a year of college chemistry following a year of high school chemistry. Besides containing this information fundamental to the further study of chemistry, the treatment of the subject is broad enough to meet the needs of the large number who do not go on in this science.

LABORATORY MANUAL IN INTRODUCTORY COLLEGE CHEMISTRY

☞ **by Joseph A. Babor and Alexander Lehrman**
Ready May, 1940 8½″ x 11″ $1.75 (probable)

A COMBINED laboratory manual and notebook of about 100 experiments together with all necessary cross section paper and table of logarithms, table of atomic weights, and the periodic table. Each experiment consists of discussion, directions, and problems and contains a list of apparatus and chemicals needed. More experiments are included than are needed for one year's work to permit each instructor to make a selection according to his needs and equipment.

Perkin and Kipping's

ORGANIC CHEMISTRY

by F. Stanley Kipping, University College, Nottingham and F. Barry Kipping, Cambridge University

1029 pages 5″ x 7½″ $6.00
Revised Edition—Published April, 1941

THIS thoroughly revised new edition of a standard of nearly half a century is now offered for the first time in one volume. The principal additions concern new compounds, new general reactions, and short references to modern large-scale synthetical processes. Complete new chapters have been added on the chemistry of the steroids and the theory of resonance and its application to various types of organic compounds. It is unquestionably the most complete and up-to-date one-volume reference work on organic chemistry now available.

EXPERIMENTAL GENERAL CHEMISTRY

by J. W. Neckers, T. W. Abbott, and K. A. Van Lente, Southern Illinois State Normal University

282 pages, 22 illustrations, 8½″ x 11″, $1.75
Published July, 1940

THE thoroughness and attention to detail with which this laboratory manual has been worked out has already won many users although published only last July. Each one of the 61 experiments is preceded by a "Preliminary Exercise" which the student is to answer and hand in *before* the laboratory period. At strategic points in each experiment there is an indication that the OK of the instructor is required. A new edition is being keyed to the new Babor and Lehrman INTRODUCTORY COLLEGE CHEMISTRY.

Babor and Lehrman

GENERAL COLLEGE CHEMISTRY

659 pages 6″ x 9″ $3.75
Second Edition—Published February, 1940

THIS thoroughly revised textbook is scoring an immediate hit and has already sold more than half as many copies as the total of the previous eleven years of the first edition. It should not be confused with INTRODUCTORY COLLEGE CHEMISTRY by the same authors as it is intended for students who *have* had high school chemistry or physical science.

LABORATORY MANUAL IN GENERAL COLLEGE CHEMISTRY

289 pages 46 illustrations 8½″ x 11″ $1.75
Second Edition—Published March, 1940

Incorporates practically all the features mentioned in the authors' *Laboratory Manual in Introductory College Chemistry.*

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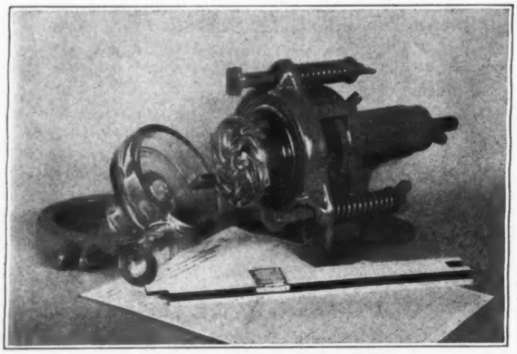

Like the larger pump, this new size is actually constructed of glass, volute, head and rotating impeller, and is fully transparent, and the same advantages are claimed for it where corrosive liquids or liquids which must be kept chemically uncontaminated are to be handled. A mechanical seal replaces the conventional stuffing box, and a safety unloading device is said to eliminate the possibility of fracture of the glass casing. The manufacturers claim that this pump will handle hot acids or brine cooled liquids with equal facility and should offer the solution to many chemical, process, and food plant problems.

Further information may be obtained by writing the *Nash Engineering Company, South Norwalk, Conn.*

New Laboratory Apparatus Catalog

A new catalog of laboratory apparatus has just been published by the *American Instrument Company of Silver Spring, Maryland.* The Catalog contains 184 pages describing instruments and apparatus for chemical, biological, physical, clinical, pathological, research, engineering and materials testing laboratories. It presents recent additions to the company's line, and includes useful data that enable the laboratory worker to select the most suitable and reliable controls and other devices for constant temperature applications. Another new feature is the section devoted to laboratory and field instruments used by soil chemists, agricultural chemists, and agronomists.

This catalog is available upon application on business or professional stationery. Ask for catalog XW 41.

Rotameter, Sight Flow Meters

The announcement of Fischer and Porter Rotameters with precision-bore tubes has created an entirely new trend in flow rate measurement, according to the claims of the manufacturers. They further state that while the rotameter is based on principles so old that patents date back as far as 1879, it was not until the development of F. & P. precision-bore glass that the rotameter attained real commercial significance.

A seventy-five page catalog on $8^1/_2'' \times 11''$ glazed paper, well bound, describes in detail the Rotameter and its uses, and every page of description is well illustrated.

As the pages of this catalog are turned, the items described appear in the following order: Operating principle and design; F. & P. precision-bore tubes (each tube of a given size is said to be interchangeable with any other tube of the same size—tolerance being 0.0006″ for the largest tubes and as low as 0.0002″ for the smaller tubes); a schematic diagram showing points of installation in a continuous distillation unit; a list of 150 substances (from acetic acid to zinc sulfate) that can be metered; a flow sheet showing their use in the viscose rayon industry. There are several pages describing the post type rotameters and their use with pulsating flow, with vapors containing condensibles and with opaque fluids. There follows then a discussion of panel mounting and the case type meter. A section on laboratory rotameters said to measure gas and vapor flows as low as 5 ml. per minute and liquid flows as small as 0.1 cc. per minute. Then described are the following types: All-glass, horizontal line, dial valve, product gages and tail boxes, rotameters of special corrosion resistant materials, alarm devices for rotameters, twin and multiple units, armored rotameters, aviation rotameters, direct reading fuel flow type, anti-ice type, and rotameters for dynamometer engine test units and for overhaul service, for oxygen control and for remote reading fuel flow.

Finally there are twelve pages devoted to the "Theory of the Rotameter and Correction Factors." In this section are presented graphs and tables to illustrate the treatment which is both descriptive and mathematical.

The above described catalog may be obtained by writing on your official letterhead to the *Fischer and Porter Co., 110 West Penn St., Germantown, Philadelphia, Pa.*

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An addition to the group of high nickel alloys has been announced by *The International Nickel Company, Inc., 67 Wall Street, New York, N. Y.* It has high strength, can be fabricated in automatic screw machinery, resists corrosion, and can be heat treated after fabrication to provide an extra measure of strength and hardness. The alloy is being produced in rod and wire forms only.

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In a 34 page catalogue the *C. J. Tagliabue Manufacturing Company, Park and Nostrand Aves. Brooklyn, N. Y.*, describes and lists detailed specifications of their electric thermometers and pyrometers of the recording and controlling type instrument.

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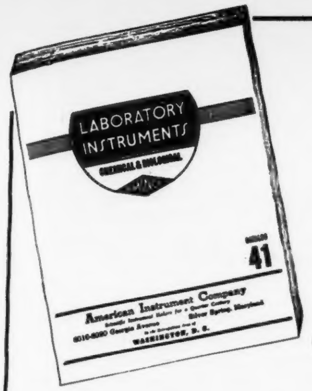

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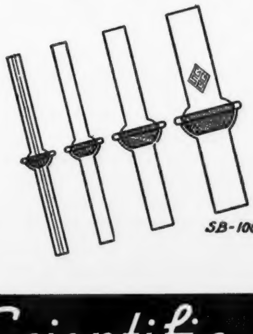

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2. **Manuscript.** The manuscript submitted should not have been published elsewhere. The work of the editorial office is facilitated and better service is assured the author when duplicate copies (the original and a carbon) are submitted. Typing of both text and references should be double-spaced, with 2–3-cm. margins. The title of the article should be followed by the name and business or institutional address of the author. If the paper has been presented at a meeting, a footnote giving name of society, date, and occasion should immediately follow the author's name. The usual editorial customs, as exemplified in the most recent issues of the Journal, should be followed as closely as possible.

Galley proof of each article will be submitted to the author. This proof should be carefully corrected and returned promptly to the *Editor's Office*. Page proof will not be submitted.

3. **References and Footnotes.** In historical and biographical articles and in papers containing only two or three literature references it is desirable that the references be handled as footnotes. Such references should be designated by superior numbers and the reference itself should be placed in the body of the text immediately following the citation and set off by rules.

In articles of the scientific review type each reference to the literature should be designated by a number, in italics (indicated in a typescript by a single underline) and enclosed in parentheses, corresponding in size with the body of the text and set in the line of reading matter. All the references are to be assembled, arranged numerically, and placed at the end of the article under the heading, Literature Cited. The numbers in parentheses are to be placed flush with the margin and if the reference exceeds one line, the succeeding line or lines should be indented. The lists of references should be typed, double-spaced.

When specific citations of previous literature are not made, but when it seems desirable to append a general bibliography, it is preferable that arrangement be made alphabetically on the basis of authors' or senior authors' names.

A reference to a periodical should include, in the order named: (1) author's name, (2) title of article with first word only, or in the case of a German title first word and nouns, capitalized (enclosed in quotation marks), (3) name of periodical (use the standard abbreviations designated in the "List of Periodicals Abstracted by *Chemical Abstracts*"), (4) volume number, (5) pages (give exact page number at which the point cited is to be found or, if the entire article is the reference, give the page numbers inclusive), (6) date of publication.

Example:

(1) Kraus and Brown, "Studies relating to organic germanium derivatives. III. Diphenyl germanium dihalides and diphenyl germanium imine," *J. Am. Chem. Soc.*, **52**, 3690–6 (1930).

A reference to a book should include, in the order named: (1) author's name, (2) title of book (enclosed in quotation marks), (3) edition, if more than one, (4) name of publisher, (5) address of publisher, (6) date of publication, (7) volume number, (8) pages (give exact page number at which the point cited is to be found or, if entire book is reference, give the total number of pages in it).

Example:

(1) Cohen, "Organic Chemistry for advanced students," 5th ed., Longmans, Green and Co., New York City, **1928**, Part I, 427 pp.

References to explanatory notes such as (1) occasion on which paper was delivered, (2) acknowledgments, (3) definitions of obscure or unfamiliar terms, (4) changes in address, etc., are to be designated in the text by superior numbers in sequence with other footnotes in article. Such a footnote should be inserted as a separate line (or lines) immediately following the word to which it refers in the text and should be separated from the text by ruled lines.

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